UNITED STATES DISTRICT COURT
SOUTHERN DISTRICT OF NEW YORK

BALCHEM CORPORATION and ALBION LABORATORIES, INC., Plaintiffs, v. DANIEL TODD EDWARDS and MIL AGRO, INC., Defendants.	**Civil Action No.: 7:18-CV-02677-KMK**

ANSWER, AFFIRMATIVE DEFENSES, AND COUNTERCLAIMS OF

DEFENDANTS DANIEL TODD EDWARDS AND MIL AGRO, INC.

Defendants Daniel Todd Edwards, an individual ("Edwards"), and Mil Agro, Inc., a Utah corporation, ("Mil Agro") (collectively "Defendant"), through its undersigned attorneys, answers Plaintiff Balchem Corporation ("Balchem") and Albion Laboratories, Inc.'s, ("Albion") (collectively "Plaintiff") Complaint and Demand for Jury Trial ("Complaint") filed in the above caption action ("Action") as follows:

Introduction

Regarding the unnumbered paragraphs under the caption "Introduction," Defendant responds that it admits that: Plaintiff filed suit against Edwards in 2016 based on the Plaintiff's allegations relating to trade secrets and that the parties settled the 2016 action by entering into a Mutual General Release and Settlement Agreement ("Settlement Agreement") as well as an Addendum and Modification Agreement to Edwards' Confidentiality, Non-Solicitation and Non-

Competition Agreement (the "CNNA") (the "CNNA Addendum"). Defendant denies each and every remaining allegation in the unnumbered paragraphs under the caption "Introduction."

Parties

1. Defendant lacks information sufficient to admit or deny the allegations of this paragraph and therefore denies the allegations of Paragraph 1.

2. Defendant lacks information sufficient to admit or deny the allegations of this paragraph and therefore denies the allegations of Paragraph 2.

3. Defendant admits the allegation of Paragraph 3.

4. Defendant admits Mil Agro is a Utah corporation with its principal place of business in Hyrum, Utah and that Edwards is the registered agent, treasurer, director, president, and secretary for Mil Agro. Defendant also admits that Edwards is an executive and director of Mil Agro and also owns a controlling interest in Mil Agro. Defendant denies the remaining allegations of Paragraph 4.

Jurisdiction and Venue

5. Defendant admits that Edwards signed the CNNA, which includes a provision, which states:

> The parties, being desirous of having any disputes resolved in a forum having a substantial body of law and experience with matters contained herein, agree that any action or proceeding with respect to this Agreement shall be brought in the Supreme Court of the State of New York, County of Orange, or in the United States District Court for the Southern District of New York, and the parties agree to the jurisdiction thereof.

Defendant denies the remaining allegations of Paragraph 5.

6. Defendant denies the allegations of Paragraph 6.

7. Defendant admits the Complaint appears to allege a cause of action pursuant to 18 U.S.C. § 1836. Defendant denies the remaining allegations of Paragraph 7.

8. Defendant admits the Complaint appears to allege a cause of action pursuant to 28 U.S.C. § 1331. Defendant denies the remaining allegations of Paragraph 8.

9. Defendant admits that Edwards signed the CNNA, which includes a provision, which states:

> The parties, being desirous of having any disputes resolved in a forum having a substantial body of law and experience with matters contained herein, agree that any action or proceeding with respect to this Agreement shall be brought in the Supreme Court of the State of New York, County of Orange, or in the United States District Court for the Southern District of New York, and the parties agree to the jurisdiction thereof.

Defendant denies the remaining allegations of Paragraph 9.

Response to General Allegations

10. Defendant lacks information sufficient to admit or deny the allegations of this paragraph and therefore denies the allegations of Paragraph 10.

11. Defendant lacks information sufficient to admit or deny the allegations of this paragraph and therefore denies the allegations of Paragraph 11.

12. Defendant lacks information sufficient to admit or deny the allegations of this paragraph and therefore denies the allegations of Paragraph 12.

13. Defendant lacks information sufficient to admit or deny the allegations of this paragraph and therefore denies the allegations of Paragraph 13.

14. Defendant lacks information sufficient to admit or deny the allegations of this paragraph and therefore denies the allegations of Paragraph 14.

15. Defendant lacks information sufficient to admit or deny the allegations of this paragraph and therefore denies the allegations of Paragraph 15.

16. Defendant lacks information sufficient to admit or deny the allegations of this paragraph and therefore denies the allegations of Paragraph 16.

17. Defendant lacks information sufficient to admit or deny the allegations of this paragraph and therefore denies the allegations of Paragraph 17.

18. Defendant lacks information sufficient to admit or deny the allegations of this paragraph and therefore denies the allegations of Paragraph 18.

19. Defendant lacks information sufficient to admit or deny the allegations of this paragraph and therefore denies the allegations of Paragraph 19.

20. Defendant lacks information sufficient to admit or deny the allegations of this paragraph and therefore denies the allegations of Paragraph 20.

21. Defendant lacks information sufficient to admit or deny the allegations of this paragraph and therefore denies the allegations of Paragraph 21.

22. Defendant lacks information sufficient to admit or deny the allegations of this paragraph and therefore denies the allegations of Paragraph 22.

23. Defendant lacks information sufficient to admit or deny the allegations of this paragraph and therefore denies the allegations of Paragraph 23.

24. Defendant lacks information sufficient to admit or deny the allegations of this paragraph and therefore denies the allegations of Paragraph 24.

25. Defendant lacks information sufficient to admit or deny the allegations of this paragraph and therefore denies the allegations of Paragraph 25.

26. Defendant lacks information sufficient to admit or deny the allegations of this paragraph and therefore denies the allegations of Paragraph 26.

27. Defendant admits the allegations of paragraph 27.

28. Defendant denies the allegations of Paragraph 28.

Response to the Balchem Acquisition and the CNNA

29. Defendant admits Edwards executed the CNNA while employed by Balchem. Defendant denies the remaining allegations of Paragraph 29.

30. Defendant admits section 2(a) of the CNNA speaks for itself. Defendant denies any remaining allegations of Paragraph 30.

31. Defendant admits section 2(c) of the CNNA speaks for itself. Defendant denies any remaining allegations of Paragraph 31.

32. Defendant admits section 6(b) of the CNNA speaks for itself. Defendant denies any remaining allegations of Paragraph 32.

33. Defendant admits section 8 of the CNNA speaks for itself. Defendant denies any remaining allegations of Paragraph 33.

34. Defendant admits the allegations of paragraph 34.

35. Defendant admits the allegations of Paragraph 35.

36. Defendant denies the allegations of Paragraph 36.

Response to the 2016 Lawsuit

37. Defendant admits the allegations of Paragraph 37.

38. Defendant admits that the 2016 Complaint, which was dismissed with prejudice, speaks for itself. Defendant denies the remaining allegations of Paragraph 38.

39. Defendant admits that the 2016 Complaint, which was dismissed with prejudice, speaks for itself. Defendant denies the remaining allegations of Paragraph 39.

40. Defendant admits that the 2016 Complaint, which was dismissed with prejudice, speaks for itself. Defendant denies the remaining allegations of Paragraph 40.

41. Defendant admits that the 2016 Complaint, which was dismissed with prejudice, speaks for itself. Defendant denies the remaining allegations of Paragraph 41.

42. Defendant admits that the 2016 Complaint, which was dismissed with prejudice, speaks for itself. Defendant denies the remaining allegations of Paragraph 42.

43. Defendant admits that the 2016 Complaint, which was dismissed with prejudice, speaks for itself. Defendant denies the remaining allegations of Paragraph 43.

44. Defendant admits that the 2016 Complaint, which was dismissed with prejudice, speaks for itself. Defendant denies the remaining allegations of Paragraph 44.

45. Defendant admits Edwards received a copy of the 2016 Complaint. Defendant denies the remaining allegations of Paragraph 45.

Response to the 2017 Settlement

46. Defendant admits the allegations of Paragraph 46.

47. Defendant admits that the Settlement Agreement speaks for itself. Defendant denies the remaining allegations of Paragraph 47.

48. Defendant admits that the Settlement Agreement speaks for itself. Defendant denies the remaining allegations of Paragraph 48.

49. Defendant admits the allegations of Paragraph 49.

50. Defendant admits that the CNNA Addendum speaks for itself. Defendant denies the remaining allegations of Paragraph 50.

51. Defendant admits that the CNNA Addendum speaks for itself. Defendant denies the remaining allegations of Paragraph 51.

52. Defendant admits that the CNNA Addendum speaks for itself. Defendant denies the remaining allegations of Paragraph 52.

53. Defendant admits that the CNNA Addendum speaks for itself. Defendant denies the remaining allegations of Paragraph 53.

54. Defendant admits that the CNNA Addendum speaks for itself. Defendant denies the remaining allegations of Paragraph 54.

55. Defendant lacks information sufficient to admit or deny the allegations of this paragraph and therefore denies the allegations of Paragraph 55.

Response to Allegations of Trade Secret Misappropriation and Breach of Contract

56. Defendant denies the allegations of Paragraph 56.

57. Defendant denies the allegations of Paragraph 57.

58. Defendant denies the allegations of Paragraph 58.

59. Defendant denies the allegations of Paragraph 59.

60. Defendant denies the allegations of Paragraph 60.

61. Defendant denies the allegations of Paragraph 61.

Response to Allegations Regarding Advertising by Edwards and Mil Agro

62. Defendant lacks information sufficient to admit or deny the allegations of this paragraph and therefore denies the allegations of Paragraph 62.

63. Defendant lacks information sufficient to admit or deny the allegations of this paragraph and therefore denies the allegations of Paragraph 63.

64. Defendant lacks information sufficient to admit or deny the allegations of this paragraph and therefore denies the allegations of Paragraph 64.

65. Defendant admits the allegations of Paragraph 65.

66. Defendant admits that Mil Agro's Safety Data Sheet ("SDS") for the Keylamax Calcium 8% product speaks for itself. Defendant denies the remaining allegations of Paragraph 66.

67. Defendant admits that Mil Agro's Keylamax Calcium 8% SDS is available on Mil Agro's website. Defendant denies the remaining allegations of Paragraph 67.

68. Defendant admits that Mil Agro's SDS are available on Mil Agro's website and that the documents speak for themselves. Defendant denies the remaining allegations of Paragraph 68.

69. Defendant denies the allegations of Paragraph 69.

70. Defendant denies the allegations of Paragraph 70.

71. Defendant denies the allegations of Paragraph 71.

72. Defendant denies the allegations of Paragraph 72.

73. Defendant denies the allegations of Paragraph 73.

74. Defendant denies the allegations of Paragraph 74.

75. Defendant admits that Mil Agro's marketing documents speak for themselves. Defendant denies the remaining allegations of Paragraph 75.

76. Defendant denies the allegations of Paragraph 76.

77. Defendant denies the allegations of Paragraph 77.

78. Defendant admits that Mil Agro's marketing documents speak for themselves. Defendant denies the remaining allegations of Paragraph 78.

79. Defendant denies the allegations of Paragraph 79.

80. Defendant denies the allegations of Paragraph 80.

81. Defendant admits that Mil Agro's marketing documents speak for themselves. Defendant denies the remaining allegations of Paragraph 81.

82. Defendant denies the allegations of Paragraph 82.

83. Defendant denies the allegations of Paragraph 83.

84. Defendant denies the allegations of Paragraph 84.

85. Defendant admits that Mil Agro's marketing documents speak for themselves. Defendant denies the remaining allegations of Paragraph 85.

86. Defendant admits that Mil Agro's marketing documents speak for themselves. Defendant lacks information sufficient to admit or deny the remaining allegations of this paragraph and therefore denies the remaining allegations of Paragraph 86.

87. Defendant admits that Mil Agro's marketing documents speak for themselves. Defendant denies the remaining allegations of Paragraph 87.

88. Defendant admits that Mil Agro's marketing documents speak for themselves. Defendant denies the remaining allegations of Paragraph 88.

89. Defendant denies the allegations of Paragraph 89.

90. Defendant denies the allegations of Paragraph 90.

91. Defendant denies the allegations of Paragraph 91.

Answer to Count I – Alleged Misappropriation of Trade Secrets

92. Defendant repeats its responses to the preceding paragraphs and incorporates them herein by reference.

93. Defendant lacks information sufficient to admit or deny the allegations of this paragraph and therefore denies the allegations of Paragraph 93.

94. Defendant denies the allegations of Paragraph 94.

95. Defendant lacks information sufficient to admit or deny the allegations of this paragraph and therefore denies the allegations of Paragraph 95.

96. Defendant denies the allegations of Paragraph 96.

Answer to Count II – Alleged Breach of Contract

97. Defendant repeats its responses to the preceding paragraphs and incorporates them herein by reference.

98. Defendant lacks information sufficient to admit or deny the allegations of this paragraph and therefore denies the allegations of Paragraph 98.

99. Defendant denies the allegations of Paragraph 99.

100. Defendant denies the allegations of Paragraph 100.

101. Defendant denies the allegations of Paragraph 101.

102. Defendant denies the allegations of Paragraph 102.

103. Defendant denies the allegations of Paragraph 103.

104. Defendant denies the allegations of Paragraph 104.

105. Defendant denies the allegations of Paragraph 105.

Answer to Count III – Alleged False Advertising (Lanham Act)

106. Defendant repeats its responses to the preceding paragraphs and incorporates them herein by reference.

107. Defendant denies the allegations of Paragraph 107.

108. Defendant denies the allegations of Paragraph 108.

109. Defendant lacks information sufficient to admit or deny the allegations of this paragraph and therefore denies the allegations of Paragraph 109.

110. Defendant lacks information sufficient to admit or deny the allegations of this paragraph and therefore denies the allegations of Paragraph 110.

111. Defendant denies the allegations of Paragraph 111.

Response to Plaintiff's Request for Relief

112. Defendant is not required to respond to the "Prayer for Relief" in the Complaint. Nonetheless, to the extent that the paragraphs of the Complaint under that heading may be deemed to allege any factual or legal entitlements to the relief requested, Defendant denies each and every such allegation, and specifically denies that Plaintiff is entitled to the requested, or any, relief. Defendant further denies each and every allegation not specifically admitted herein.

Additional and Affirmative Defenses

Without admitting or acknowledging what must be alleged by way of affirmative defenses or that Defendant bears the burden of proof as to any of the defenses set forth herein; Defendant alleges the following as additional or affirmative defenses to the Complaint, to the purported claims therein, and to the relief sought therein.

First Affirmative Defense: Failure to State a Claim

The Complaint fails to state a claim against Defendants upon which relief can be granted.

Second Affirmative Defense: Personal Jurisdiction

Mil Agro is not a party to either the CNNA or the CNNA Addendum, and has never consented to the Jurisdiction of the Southern District of New York. The Complaint fails to plead facts that confer personal jurisdiction of the Southern District of New York over Mil Agro.

Third Affirmative Defense: Improper Venue

Mil Agro is not a party to either the CNNA or the CNNA Addendum, and never consented to the venue of the Southern District of New York.

Fourth Affirmative Defense: Public Domain

Plaintiff's alleged trade secrets are not secret or have otherwise entered the public domain through no fault of Edwards or Mil Agro.

Fifth Affirmative Defense: Opinion or Puffery

Statements contained in Defendant's marketing documents express opinions or otherwise appropriately comprise puffery.

Sixth Affirmative Defense: True Statements

Statements contained in Defendant's marketing documents are true and not misleading.

Seventh Affirmative Defense: Failure to Perform

Plaintiff has failed to perform its obligations under the CNNA Addendum including at least the mandatory dispute resolution procedures contained in section 2(i).

Eighth Affirmative Defense: Lack of Personal Liability

Defendant denies that there is any liability with respect to Plaintiff's allegations of false advertising under the Lanham Act. However, to the extent there is liability for false advertising, there can be no liability imputed to Edwards personally as all such allegations are related to statements made in Mil Agro's advertising or otherwise related to Mil Agro's activity as a corporate entity.

Ninth Affirmative Defense: Res Judicata

Plaintiff's 2016 Complaint was dismissed with prejudice. Plaintiff has now relied on facts pleaded in the 2016 Complaint that was dismissed with prejudice. Plaintiff is barred in whole or in part from bringing any claim related to the prejudicially dismissed 2016 Complaint.

Tenth Affirmative Defense: Release of Claims

Plaintiff and Edwards entered into the 2017 Settlement Agreement, which included a release of all causes of action related to the 2016 Complaint, based on facts known, unknown, and to be later discovered. Plaintiff's claims are barred by the mutual release of claims set forth in the 2017 Settlement Agreement.

Eleventh Affirmative Defense: Public Policy

The provisions of the agreements relied upon by the Plaintiff are invalid as violative of the laws and/or policies of this jurisdiction.

Further Additional Defenses

In addition to the defenses set forth above, Defendant reserves the right to raise, assert, rely upon, or add any and new or additional defenses under Rule 8(c) of the Federal Rules of Civil Procedure ["Rules(s)"], the laws of the United States, the laws of any other governing jurisdictions that may exist or in the future be applicable based on discovery and further factual investigation in this Action, and reserves the right to amend any and all defenses set forth above as discovery proceeds.

DEFENDANTS COUNTERCLAIMS

Pursuant to Rule 13(a), Defendant counterclaims (the "Counterclaims") against Plaintiff as follows:

Jurisdiction and Parties

1. Defendant's Counterclaims seek damages relating to Plaintiff's breach of the CNNA Addendum. This Court has supplemental jurisdiction over Defendant's Counterclaims because those claims are part of the same case or controversy as the claims asserted in Plaintiff's Complaint.

2. This Court has personal jurisdiction over Balchem and Albion in that Plaintiff invoked and consented to the jurisdiction of this Court by filing the Complaint.

3. An actual case or controversy exists as to whether or not the Plaintiff has any trade secrets, and if the Defendant is contractually bound not to use such alleged trade secrets.

4. This Court has jurisdiction to provide declaratory relief under 28 U.S.C. § 2201.

5. Venue is proper in this jurisdiction, with respect to Defendant's Counterclaims, pursuant to 28 U.S.C. § 1391.

6. The CNNA is a legally binding agreement between Edwards and Plaintiff.

7. The CNNA Addendum is a legally binding agreement between Edwards and Plaintiff.

8. Section 2(i) (the "Compliance Verification") of the CNNA Addendum states:

> **Compliance Verification**. At any time BALCHEM reasonably believes that Todd may be in violation of the terms of the CNNA (which, for purposes of this paragraph includes this Addendum), BALCHEM may give notice to Todd asking for reasonable further assurances of Todd's compliance with the CNNA. If BALCHEM does not accept such assurances, however, BALCHEM and Todd shall then agree upon a neutral and independent third party who, upon acceptance of such responsibility and execution and delivery of appropriate Confidentiality and Nondisclosure Agreements, shall review Todd's then current business activities, including onsite evaluations if necessary, to determine whether there exists evidence of a material breach of the CNNA by Todd. Todd and BALCHEM acknowledge that if they are unable to agree upon an independent third party reviewer, their dispute may become the

> subject of litigation; therefore, the parties agree to engage in a reasonable and cooperative selection process, which may include a petition to the Court for the appointment of such an independent third party reviewer in the event the parties can not otherwise agree. Todd shall cooperate with such an independent review; however, the cost of such review shall be entirely borne by BALCHEM, unless the independent reviewer shall determine that there is a material violation by Todd of the CNNA. In that event, Todd shall bear the costs of such independent review, and immediately bring his activity into compliance with the CNNA.

9. Plaintiff has communicated concern that Edwards may be in violation of the CNNA and CNNA Addendum.

10. Prior to filing suit, Plaintiff failed to meet with Edwards to agree upon a neutral and independent third party to review Edwards and Mil Agro's business activities.

11. Plaintiff failed to bear the costs of appointing a neutral and independent third party to conduct a review.

12. Plaintiff failed to bear the costs of the neutral and independent third-party's review of Defendant's business activity.

13. Plaintiff's failure to perform its obligations under the Compliance Verification has caused Edwards and Mil Agro harm and related damages.

14. The Compliance Verification is a material term of the CNNA Addendum.

15. The Settlement Agreement is a valid agreement between Edwards and the Plaintiff.

16. The Settlement Agreement required Plaintiff to release all claims against Edwards related to the 2016 complaint filed against Edwards based on facts known and unknown.

17. Plaintiff's Complaint relies on allegations originally alleged in its 2016 complaint.

Public Disclosure of the Alleged Trade Secrets

18. Edwards is not restricted from using the alleged trade secrets described by Sections 2(a)–(b), (c) if the alleged trade secrets described therein have become publicly available through no fault of Edwards.

19. Plaintiff alleges Edwards has misappropriated Balchem's product formulations as defined in Section 2(a) of the CNNA Addendum.

20. In October 2004, Albion filed U.S. Patent Application No. 10/969,584 (the "'584 Application"). A true and correct copy of the '584 Application is attached hereto as Exhibit A.

21. Albion is the original and only assignee of the '584 Application.

22. The information contained in the '584 Application became public domain information when it was published on October 27, 2005.

23. The '584 Application discloses the alleged trade secret described in Section 2(a)(i) of the CNNA Addendum.

24. Albion was and has been aware of the contents of '584 Application since it was filed in 2004.

25. Balchem, by virtue of acquiring Albion in 2016, had knowledge of the '584 Application in 2016.

26. A third-party vendor known as Ferti-Organic, Inc. ("Ferti-Organic") publicly advertises use of the alleged trade secret described in Section 2(a)(ii) of the CNNA Addendum.

27. According to Ferti-Organic, its products—including the alleged trade secret described in Section 2(a)(ii) of the CNNA Addendum—are sold to farmers in at least all 50 states of the United States.

28. The alleged trade secret described in Section 2(a)(ii) of the CNNA Addendum entered the public domain at least as early as the date Ferti-Organic began publicly selling its product.

29. On information and belief, Plaintiff became aware of the alleged trade secret described in Section 2(a)(ii) of the CNNA Addendum when it purchased product from Ferti-Organic.

30. On information and belief, Plaintiff was aware that Ferti-Organic was advertising the use of the alleged trade secret described in Section 2(a)(ii) of the CNNA Addendum prior to entering into the CNNA Addendum with Edwards.

31. U.S. Patent No. 5,298,482 (the "'482 patent") was filed on May 12, 1992. A true and correct copy of the '482 patent is attached hereto as Exhibit B.

32. The '482 patent discloses use of the alleged trade secret described in Section 2(e) of the CNNA Addendum.

33. The '482 patent has been publicly available at least since it was granted by the United States Patent Office on March 29, 1994.

Interference with Defendant's Business

34. Defendant has established business relationships with customers in at least California and Latin America.

35. In particular, Defendant has established a business relationship with the J.R. Simplot Company ("Simplot").

36. On information and belief, Plaintiff had knowledge of Defendant's business relationship with Simplot.

37. During the first quarter of 2018, Defendant had secured a commitment from Simplot to purchase products over the course of 2018.

38. Simplot required Defendant to obtain a $1 million insurance policy.

39. Defendant obtained the $1 million policy based on a projected $300,000 in sales to Simplot.

40. On information and belief, Plaintiff had knowledge of the order from Simplot.

41. On information and belief, Plaintiff interfered with Defendant's business relationships by contacting Simplot.

42. On information and belief, Plaintiff wrongfully represented to Simplot that Simplot would be embroiled in this Action if Simplot continued to conduct business with the Defendant.

43. Simplot cancelled its order and has halted its business relationship with Defendant.

44. On information and belief, Simplot's actions were based on Plaintiff's representations and interference.

45. Defendant has suffered damages as a result totaling an estimated $300,000 in lost sales.

First Cause of Action – Breach of Contract

46. Defendant repeats and re-alleges the preceding paragraphs and incorporates them herein by reference.

47. The CNNA and CNNA Addendum are binding contracts between Edwards and Plaintiff.

48. When suspecting a breach of the CNNA or CNNA Addendum, Plaintiff is required to complete the Compliance Verification process prior to filing suit in any court.

49. The Plaintiff filed this action without completing the Compliance Verification process.

50. Plaintiff has breached the CNNA Addendum by not meeting with Edwards to appoint a third-party reviewer.

51. Plaintiff has also breached the CNNA Addendum by not bearing the cost of a third-party review.

52. The Settlement Agreement is a binding contract between Edwards and Plaintiff.

53. Plaintiff agreed to release all claims based on facts known and unknown related to its complaint filed against Edwards in 2016.

54. Plaintiff has breached the Settlement Agreement by relying on facts related to the 2016 complaint in filing this Action.

55. Plaintiff's breaches have caused Edwards harm and related damages.

Second Cause of Action – Breach of Implied Covenant of Good Faith and Fair Dealing

56. Defendant repeats and re-alleges the preceding paragraphs and incorporates them herein by reference.

57. Plaintiff has failed to act in good faith with respect to the CNNA, the CNNA Addendum, and with Edwards and Mil Agro.

58. As one example, Plaintiff has not, in good faith, attempted to comply with the Compliance Verification process.

59. The alleged trade secrets described in Section 2(a) of the CNNA Addendum have been publicly available since the '584 Application was published on October 27, 2005, and since Ferti-Organic began selling and advertising its product to the public..

60. On information and belief, Plaintiff was aware that it did not have any trade secret rights to the information described in the '584 Application or to the product sold by Ferti-Organic.

61. As another example, on information and belief, despite knowing the alleged trade secrets described in Section 2(a) of the CNNA Addendum were publicly available, Plaintiff represented to Edwards—in bad faith—that Plaintiff had trade secret rights when the parties entered into the CNNA Addendum.

62. As another example, on information and belief, Plaintiff has filed this Action as an attempt to restrict Edwards and Mil Agro from fairly competing in the marketplace.

63. Plaintiff's failure to act in good faith has damaged Edwards and Mil Agro.

Third Cause of Action – Bad Faith Claim of Misappropriation (UT-UTSA)

64. Defendant repeats and re-alleges the preceding paragraphs and incorporates them herein by reference.

65. Plaintiff was and has been aware that the alleged trade secrets described in Section 2(a) of the CNNA Addendum have entered the public domain by virtue of the '584 Application and by virtue of Ferti-Organic's actions.

66. Despite knowing that the alleged trade secrets described in Section 2(a) of the CNNA Addendum have entered the public domain, Plaintiff has accused Defendant of misappropriating these alleged trade secrets under the Utah Uniform Trade Secret Act.

67. On information and belief, Plaintiff has brought a claim under the Utah Uniform Trade Secret Act in bad faith.

68. Plaintiff is in violation of Section 13-24-5 of the Utah Uniform Trade Secrets Act.

Fourth Cause of Action – Declaratory Judgement

69. Defendant repeats and re-alleges the preceding paragraphs and incorporates them herein by reference.

70. Edwards is free to use any alleged trade secret described in Section 2(a)(i) of the CNNA Addendum if it has entered the public domain through no fault of Edwards.

71. The ’584 Application discloses the alleged trade secret described in Section 2(a)(i) of the CNNA Addendum.

72. The information disclosed in the ’584 Application entered the public domain when it was published on October 27, 2005.

73. Edwards did not cause the ’584 Application to be published.

74. The alleged trade secret described in Section 2(a)(i) of the CNNA Addendum is not a trade secret.

Fifth Cause of Action – Declaratory Judgement

75. Defendant repeats and re-alleges the preceding paragraphs and incorporates them herein by reference.

76. Edwards is free to use any alleged trade secret described in Section 2(a)(ii) of the CNNA Addendum if it has entered the public domain through no fault of Edwards.

77. Ferti-Organic has publicly advertised use of the alleged trade secret described in Section 2(a)(ii) of the CNNA Addendum.

78. Ferti-Organic has customers throughout the United States that purchase and use the alleged trade secret described in Section 2(a)(ii) of the CNNA Addendum.

79. The alleged trade secret described in Section 2(a)(ii) of the CNNA Addendum has entered the public domain.

80. Edwards did not cause the alleged trade secret described in Section 2(a)(ii) of the CNNA Addendum to enter the public domain.

81. The alleged trade secret described in Section 2(a)(ii) of the CNNA Addendum is not a trade secret.

Sixth Cause of Action – Declaratory Judgement

82. Defendant repeats and re-alleges the preceding paragraphs and incorporates them herein by reference.

83. Edwards is free to use any alleged trade secret described in Section 2(e) of the CNNA Addendum if it has entered the public domain through no fault of Edwards.

84. The ’482 patent discloses the alleged trade secret described in Section 2(e) of the CNNA Addendum.

85. The information disclosed in the ’482 patent entered the public domain at least when it was granted on March 29, 1994.

86. Edwards did not cause the ’482 patent to be published.

87. The alleged trade secret described in Section 2(e) of the CNNA Addendum is not a trade secret.

Seventh Cause of Action – Tortious Interference

88. Defendant repeats and re-alleges the preceding paragraphs and incorporates them herein by reference.

89. Defendant had a valid agreement in the form of an order with Simplot.

90. On information and belief, Plaintiff had knowledge of the order.

91. On information and belief, Plaintiff wrongfully interfered with the order by at least threatening to involve Simplot in litigation—based at least in-part on allegations made in the Complaint.

92. Simplot canceled its order with the Defendant.

93. On information and belief, Simplot canceled its order based in-part on Plaintiff's interference.

94. Defendant has suffered damages in the form of lost sales revenue exceeding $300,000.

Prayer for Relief

WHEREFORE, Defendant respectfully prays that the Court enter a judgment in its favor and against Plaintiff as follows:

A. That Plaintiff take nothing by the Complaint, and for a judgment against Plaintiff, and in favor of Defendant, on all of Plaintiff's claims.

B. That the Court enter judgement in favor of Defendant on all of Defendant's claims.

C. Award Defendant actual damages, attorney's fees, and punitive damages in an amount to be determined at trial.

D. That the Court award to Defendant its costs of suit and attorneys' fees as permitted by law.

E. A declaration that the alleged trade secret described in Section 2(a)(i) of the CNNA Addendum is not a trade secret.

F. A declaration that Defendant is free to use the alleged trade secret described in Section 2(a)(i) of the CNNA Addendum.

G. A declaration that the alleged trade secret described in Section 2(a)(ii) of the CNNA Addendum is not a trade secret.

H. A declaration that Defendant is free to use the alleged trade secret described in Section 2(a)(ii) of the CNNA Addendum.

I. A declaration that the alleged trade secret described in Section 2(e) of the CNNA Addendum is not a trade secret.

J. A declaration that Defendant is free to use the alleged trade secret described in Section 2(e) of the CNNA Addendum.

DEFENDANT DEMANDS A JURY TRIAL ON ALL COUNTS SO TRIABLE

Dated: May 15, 2018

DANIEL TODD EDWARDS and MIL AGRO, INC

By: /s/ *Larry R. Laycock*

Larry R. Laycock (*admitted pro hac vice)*
Michael J. Howell (*admitted pro hac vice*)
MASCHOFF BRENNAN
111 South Main Street, Suite 600
Salt Lake City, Utah 84111
Telephone: (435) 252-1360
Facsimile: (435) 252-1361

EXHIBIT A

US 20050235718A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2005/0235718 A1**

Dickinson et al. (43) **Pub. Date: Oct. 27, 2005**

(54) **ORGANIC AMINO ACID CHELATES, METHODS FOR MAKING SUCH CHELATES, AND METHODS FOR USING SUCH CHELATES**

(76) Inventors: **Kevin Dickinson**, Layton, UT (US); **Jeremy O'Brien**, Kaysville, UT (US); **Stephen D. Ashmead**, Clinton, UT (US); **Jennifer Hartle**, Harrisville, UT (US)

Correspondence Address:
KENNETH HORTON
KIRTON & MCCONKIE
P.O. BOX 45120
SALT LAKE CITY, UT 84145-0120 (US)

(21) Appl. No.: **10/969,584**

(22) Filed: **Oct. 20, 2004**

Related U.S. Application Data

(60) Provisional application No. 60/563,940, filed on Apr. 21, 2004.

Publication Classification

(51) **Int. Cl.**[7] **C05F 1/00**

(52) **U.S. Cl.** **71/11**

(57) **ABSTRACT**

Organic approved amino acid chelate foliar fertilizer compositions, methods for making such compositions, and methods for using such compositions are described. The foliar fertilizer compositions contain only negligible amounts of wetting agents, anti-foaming agents, preservatives, anti-microbial agents, and similar additives. The foliar fertilizers are also made from starting materials that are organic-approved. Therefore, the fertilizer compositions qualify as an organic material under the respective federal or state regulations. As well, the foliar fertilizers are dried after the chelation process, rather than being kept in solution. Therefore, the foliar fertilizers can be stored and shipped inexpensively.

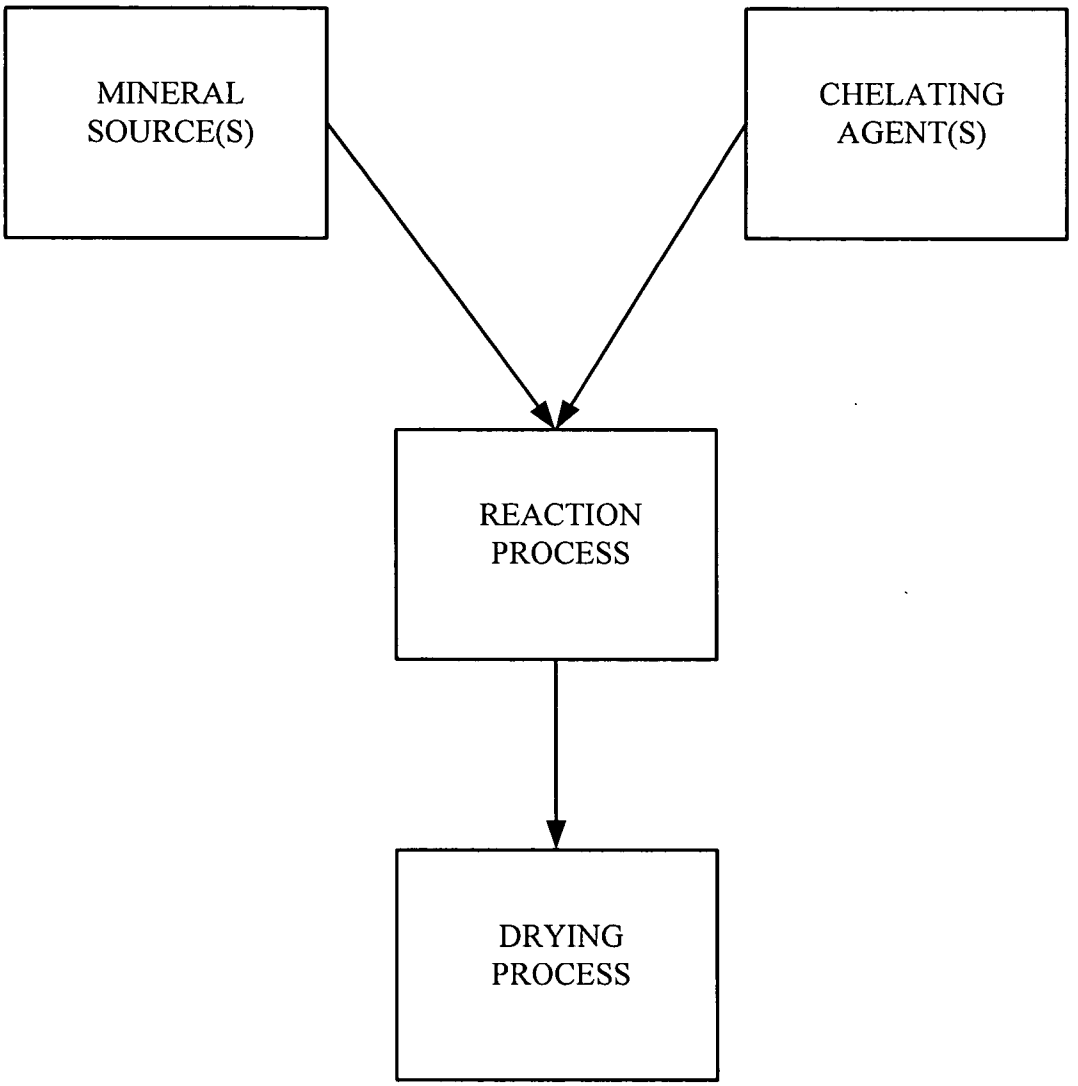

MINERAL SOURCE(S)
CHELATING AGENT(S)
REACTION PROCESS
DRYING PROCESS

FIGURE 1

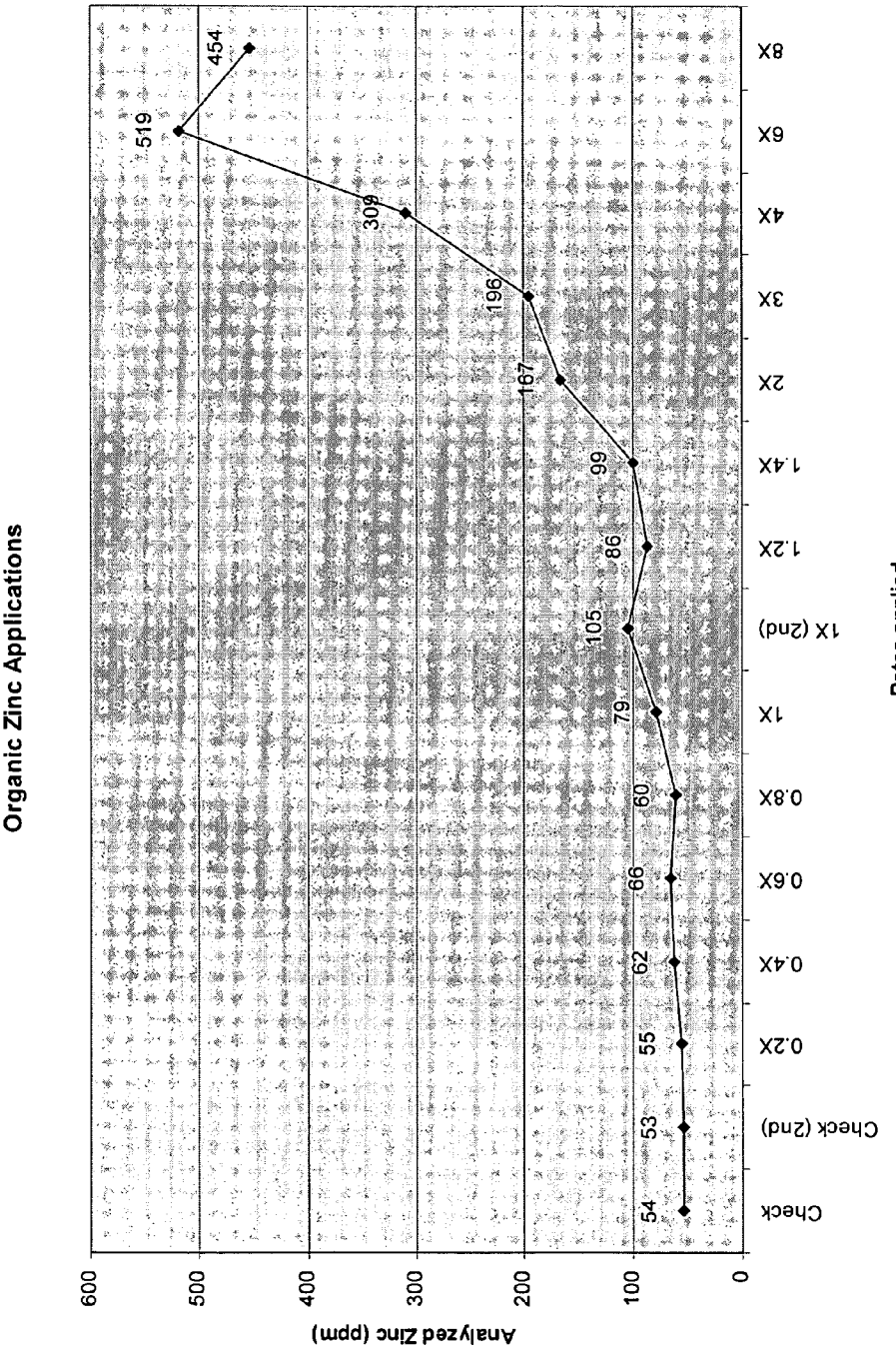

Organic Zinc Applications
Analyzed Zinc (ppm)
0
100
200
300
400
500
600
Check
Check (2nd)
0.2X
0.4X
0.6X
0.8X
1X
1X (2nd)
1.2X
1.4X
2X
3X
4X
6X
8X
Rates applied
54
53
55
62
66
60
79
105
86
99
167
196
309
519
454

FIGURE 2

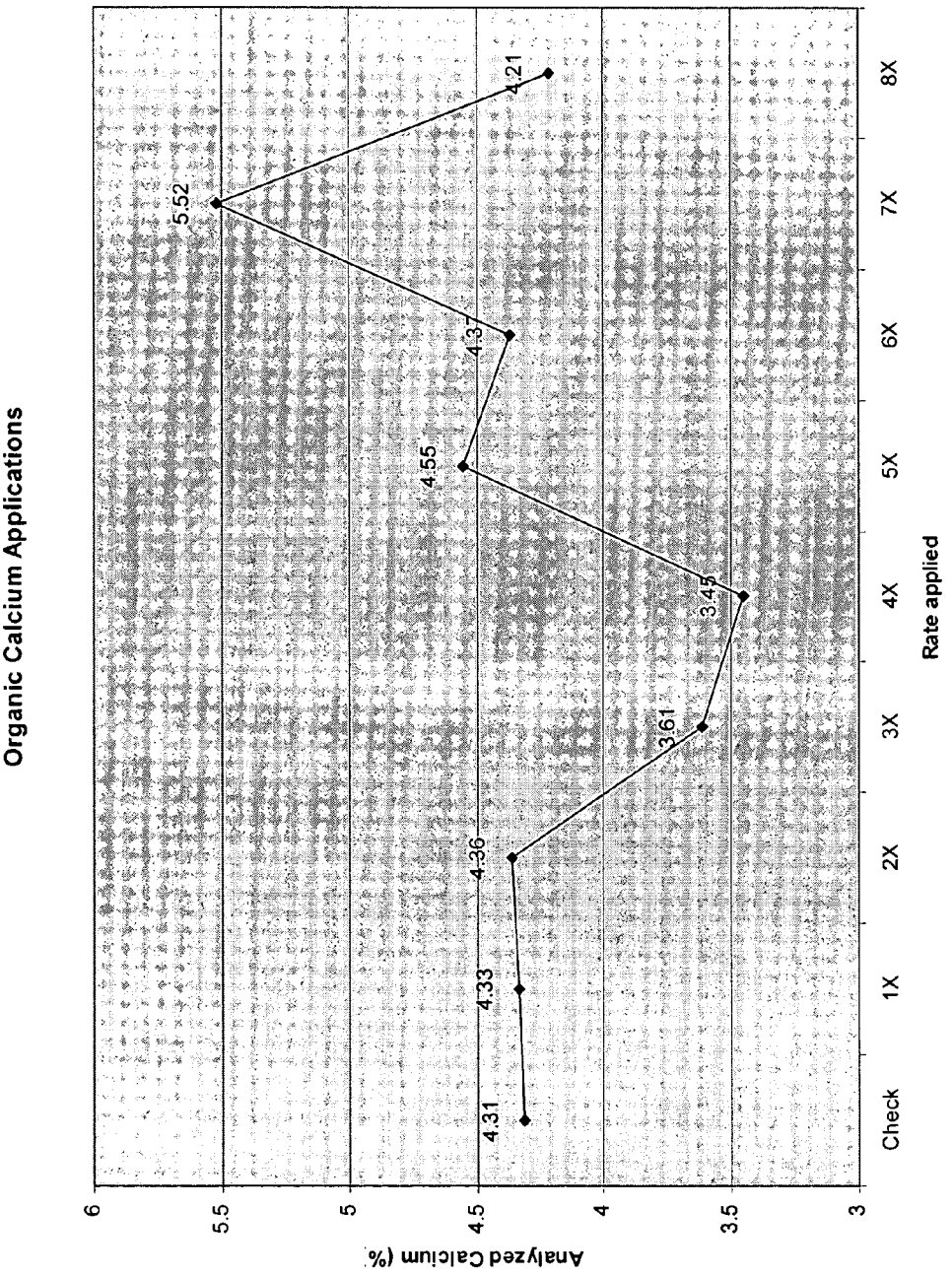

Organic Calcium Applications
Analyzed Calcium (%)
6
5.5
5
4.5
4
3.5
3
Check
1X
2X
3X
4X
5X
6X
7X
8X
Rate applied
5.52
4.31
4.33
4.36
3.61
3.45
4.55
4.3
4.21

FIGURE 3

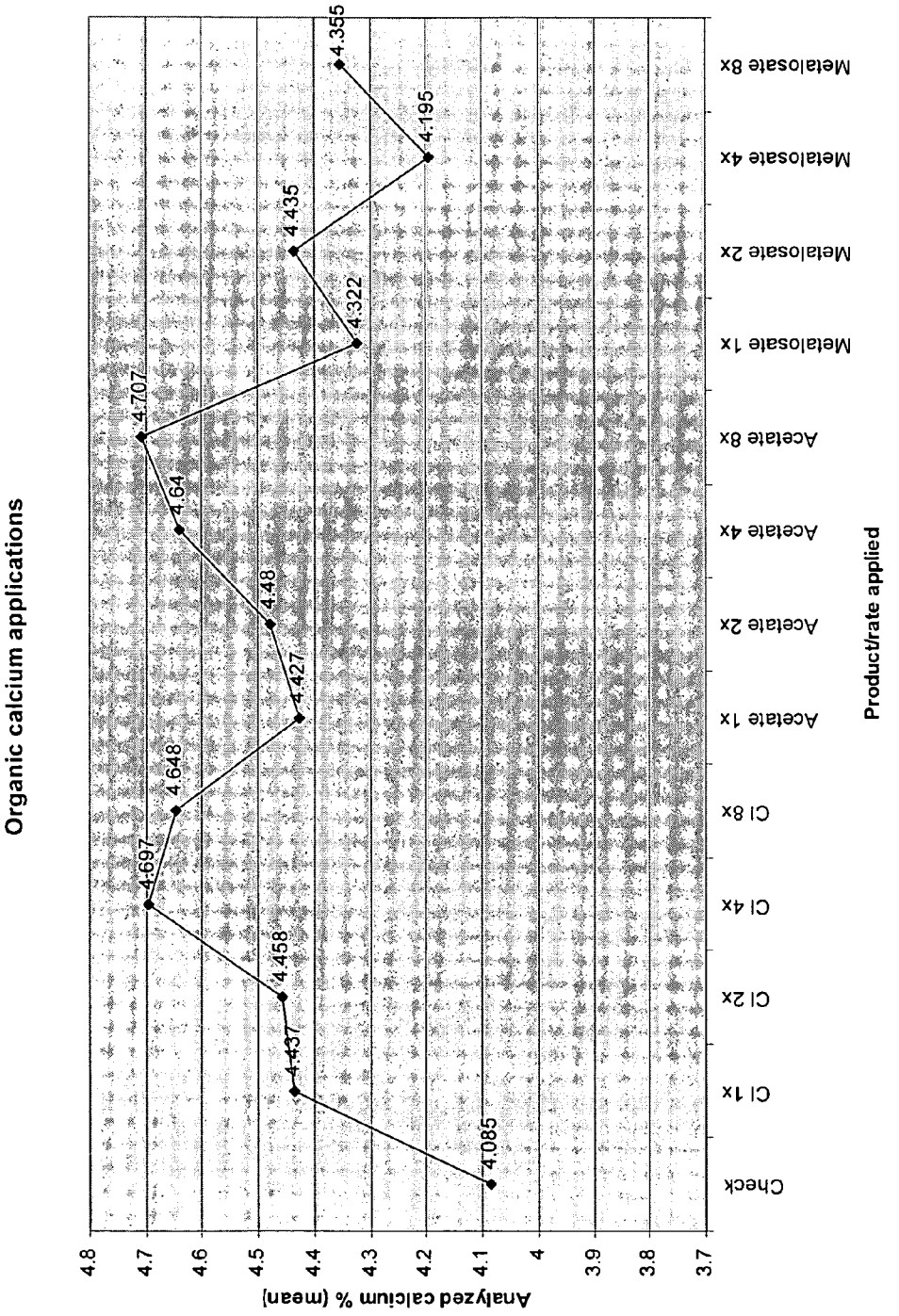

Organic calcium applications
Analyzed calcium % (mean)
4.8
4.7
4.6
4.5
4.4
4.3
4.2
4.1
4
3.9
3.8
3.7
4.085
4.437
4.458
4.697
4.648
4.427
4.48
4.64
4.707
4.322
4.435
4.195
4.355
Check
Cl 1x
Cl 2x
Cl 4x
Cl 8x
Acetate 1x
Acetate 2x
Acetate 4x
Acetate 8x
Metalosate 1x
Metalosate 2x
Metalosate 4x
Metalosate 8x
Product/rate applied

FIGURE 4

ORGANIC AMINO ACID CHELATES, METHODS FOR MAKING SUCH CHELATES, AND METHODS FOR USING SUCH CHELATES

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority of U.S. Patent Application No. 60/563,940, filed on Apr. 21, 2004, the disclosure of which is incorporated herein by reference.

FIELD OF THE INVENTION

[0002] The invention generally relates to the field of mineral amino acid chelates and methods for making and using such chelates. In particular, the invention relates to mineral amino acid chelates that are used as fertilizers. More particularly, the invention relates to mineral amino acid chelates fertilizers that are derived from specific ingredients and that comply with specific product certification guidelines.

BACKGROUND OF THE INVENTION

[0003] There are numerous types of fertilizers that are known and used in the art. One type of fertilizer is applied to the leaves of plants and often is referred to as a foliar fertilizer. One type of foliar fertilizer contains amino acid chelate compounds. When properly formed, amino acid chelates are stable products having one or more five-membered rings formed by reaction between the carboxyl oxygen, and the alpha-amino group of an alpha-amino acid with the metal ion. Such a five-membered ring is defined by the metal atom, the carboxyl oxygen, the carbonyl carbon, the alpha-carbon and the alpha-amino nitrogen. The actual structure will depend upon the ligand to metal mole ratio. See also U.S. Pat. Nos. 3,969,540, 4,020,158, 4,076,803, 4,103,003, 4,167,564, 4,169,716, 4,169,717, 4,172,072, 4,201,793, 4,216,143, 4,216,144, 4,491,464, 4,599,152, 4,725,427, 4,774,089, 4,830,716, 4,863,898, 5,162,369, 5,292,538, 5,292,729, 5,516,925, 5,596,016, 5,614,553, 5,882,685, 5,888,553, 6,114,379, 6,159,530, 6,166,071, 6,207,204, 6,294,207, 6,299,914, 6,407,138, 6,426,424, 6,458,981, 6,518,240, 6,706,904, 6,710,079, and 6,716,814, the disclosures of which are incorporated herein by reference.

[0004] Foliar fertilizers are typically prepared by using weak acids as a processing aid. The fertilizers also usually contain wetting agents and anti-foaming agents to defeat the plant's normal water repellant properties, thereby facilitating absorption of the nutrients in the foliar fertilizer by the plant. Foliar fertilizers also contain other processing aids and additives (such as suspending agents, compatability agents and emulsifying agents) that are used to enhance their properties.

[0005] Foliar fertilizers are usually maintained in solution from the time of their manufacture until they are applied to the leaves or other parts of a plant. Maintaining them in solution requires the use of preservatives to prevent the growth of bacteria and molds in the solution. These bacteria usually grow because of the specific ligands that are used in the chelating process. Additional problems also occur while the foliar fertilizer is in solution, e.g., increased costs due to shipping and increased likelihood of the chelates precipitating out of solution during storage and shipping.

[0006] Foliar fertilizers are subject to federal and state regulatory requirements because they can impact the quality of food and the environment. These requirements regulate the registration, use, and sale of the foliar fertilizers. Recently, the U.S. Department of Agriculture adopted strict guidelines for the types of ingredients and the methods of processing that can be used for foliar fertilizers. See 7 CFR Part 205 National Organic Program Final Rule, the disclosure of which is incorporated herein by reference.

[0007] These federal regulations established national standards for the production and handling of organically produced products, including a list of substances approved for—and prohibited from—use in organic production and handling. In other words, these regulations (including future amendments to these regulations and future regulations that may be enacted) require that for a material (including foliar fertilizers) to be classified as "organic," the starting material(s) for the foliar fertilizer must be naturally-occurring or fall within a specific category of synthetic material (collectively "organic-approved"). Similar regulations have also been adopted by the state of Washington. See Chapter 16-157 WAC, the disclosure of which is incorporated herein by reference. These regulations also prohibit "organic" foliar fertilizers from containing wetting agents, anti-foaming agents, and preservatives.

SUMMARY OF THE INVENTION

[0008] The invention relates to organic amino acid chelate foliar fertilizer compositions, methods for making such compositions, and methods for using such compositions. The foliar fertilizer compositions contain only negligible amounts of wetting agents, anti-foaming agents, preservatives, anti-microbial agents, and similar additives. The foliar fertilizers are also made from starting materials that are organic-approved. Therefore, the fertilizer compositions qualify as an organic material under the respective federal or state regulations. As well, the foliar fertilizers are dried after the chelation process, rather than being kept in solution. Therefore, the foliar fertilizers can be stored and shipped inexpensively.

BRIEF DESCRIPTION OF THE FIGURES

[0009] The following description of the invention can be understood in light of the Figures, in which:

[0010] **FIG. 1** illustrate a process of making the amino acid chelate compounds in one aspect of the invention; and

[0011] **FIGS. 2-4** depict the results of methods of using the foliar fertilizers in several aspects of the invention.

[0012] **FIGS. 1-4** presented in conjunction with this description are views of only particular—rather than complete—portions of the compositions and methods of making and using the compositions according to the invention. Together with the following description, the Figures demonstrate and explain the principles of the invention. In the Figures, the thickness of layers and regions are exaggerated for clarity. The same reference numerals in different drawings represent the same element, and thus their descriptions will be omitted.

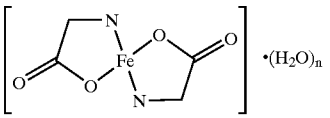
DETAILED DESCRIPTION OF THE INVENTION

[0013] The following description provides specific details in order to provide a thorough understanding of the inven-

tion. The skilled artisan, however, would understand that the invention can be practiced without employing these specific details. Indeed, the invention can be practiced by modifying the illustrated method and resulting product and can be used in conjunction with apparatus and techniques conventionally used in the industry. The invention described below deals primarily with amino acid chelate foliar fertilizers for application to plants. The invention, however, could be modified for other uses, such as nutritional supplements for animals or humans. In addition, other chelating ligands could also be used instead of amino acids, such as organic acids containing ascorbic acid, citric acid, tartaric acid, acetic acid, fulvic acid, humic acid and the like, as well as lignin solfonate.

[0014] As described above, the invention includes amino acid chelate foliar fertilizers that can be classified as organic. To be so classified, the foliar fertilizers of the invention contain negligible or no amounts of wetting agents, anti-foaming agents, anti-microbial agents, preservatives, and similar additives. As well, the foliar fertilizers are made from starting materials that can be classified as organic-approved. Any foliar fertilizer exhibiting these properties is included within the scope of the invention, including those described below.

[0015] The structure and chemistry of amino acid chelates are well known. See, for example, Ashmead et al., *Chelated Mineral Nutrition,* (1982), Chas. C. Thomas Publishers, Springfield, Ill.; Ashmead et al., *Intestinal Absorption of Metal Ions,* (1985), Chas. C. Thomas Publishers, Springfield, Ill.; Ashmead et al., *Foliar Feeding of Plants with Amino Acid Chelates,* (1986), Noyes Publications, Park Ridge, N.J.; U.S. Pat. Nos. 4,020,158; 4,167,564; 4,216,143; 4,216,144; 4,599,152; 4,774,089; 4,830,716; 4,863,898; and 4,725,427; the entire disclosures of which are incorporated by reference. As a brief exemplary explanation, amino acid chelates and complexes are compounds that contain metal ions bonded to amino acid ligands. In the case of amino acid chelates, the compounds form one or more heterocyclic rings. For example, the chemical structure of ferrous amino acid chelate (or ferrous biglycinate chelate) is



[0016] where an atom of iron is bonded to two molecules of glycine. The chemical bond at the carboxyl oxygen group may be coordinate covalent, covalent, and/or ionic. At the alpha-amino group, the chemical bond is typically a covalent or coordinate covalent bond.

[0017] Any organic amino acid can be used as the ligand for the chelates in the invention. Examples of such ligands include naturally-occurring single amino acids like alanine, arginine, asparagine, aspartic acid, cysteine, cystine, glutamine, glutamic acid, glycine, histidine, hydroxyproline, isoleucine, leucine, lysine, methionine, ornithine, phenylalanine, proline, serine, threonine, tryptophan, tyrosine, valine, and combinations thereof. Ligands other than single amino acids (e.g. dipeptides, tripeptides, tetrapeptides, and other polypeptides formed by any combination of the single amino acids) may also be used as the organic amino acid ligand.

[0018] The amino acids are typically chelated to minerals to obtain the stable form of the compound. The minerals that can be used in the compounds include any transition metal, any alkaline earth metal, boron, Se, K, as well as calcium, copper, iron, magnesium, manganese, and zinc.

[0019] The foliar fertilizers of the invention can contain any amount of additives (e.g., wetting agents, anti-foaming agents, anti-microbial agents, preservatives, and similar additives) that will allow the foliar fertilizer to be classified as organic under the respective regulation (whether present or future). In one aspect of the invention, the foliar fertilizers contain only negligible amounts (i.e., up to about 0.1 wt %) of such additives.

[0020] Thus, the foliar fertilizers can contain up to about 0.1 wt % wetting agents, up to about 0.1 wt % anti-foaming agents, up to about 0.1 wt % anti-microbial agents, up to about 0.1 wt % preservatives, and up to about 0.1 wt % of similar additives. In another aspect of the invention, the foliar fertilizers of the invention contain only trace amounts of such additives. In yet another aspect of the invention, the foliar fertilizers of the invention contain only about 0 wt % of such additives.

[0021] The foliar fertilizers contain limited (or no amounts) of such additives that are conventionally used because their inclusion is prohibited by the certification regulations. To the extent such additives or other materials (whether they are now known and not used or whether they are discovered) can become organic-approved, they can be used in the foliar fertilizers of the invention. As well, the foliar fertilizers could be modified to be organic-approved under governmental regulations other than those described herein.

[0022] The foliar fertilizers of the invention can be made or produced in either a liquid or a solid form. In one aspect of the invention, the foliar fertilizers are in a solid form. The foliar fertilizer can be made in any solid form known in the art, including powders, tablets, capsules, or granules.

[0023] The foliar fertilizers of the invention are made by any process that manufactures the compositions with the properties described above. In one aspect of the invention, and as illustrated in **FIG. 1**, the foliar fertilizers are made by mixing or reacting an organic-approved mineral source with a chelating agent in an aqueous solution. In one aspect of the invention, the pH of the solution can range from about 6 to about 9. The aqueous solution serves to effect the chelation or complexation reaction and may include de-ionized, non-deionized, de-aerated, or non-deaereated, filtered or unfiltered water.

[0024] Any chelating agent known in the art can be used in this reaction. Examples of such chelating agents include any known hydrolyzed vegetable protein, yeast, naturally occurring organic acids, algae extracts, and other organic-approved sources. Examples of hydrolyzed vegetable proteins include soy, rice, and wheat. Of course, any other chelating agent listed in the respective regulation(s) can also be used in the invention.

[0025] The mineral source that is used in the reaction includes any material that is approved as organic by the

regulatory guidelines discussed above. Examples of such materials include elemental metals, metal sulfates, metal oxides, metal carbonates, metal chlorides, metal borates, and combinations thereof. Examples of metal sulfates that can be used include sulfates of iron, zinc, magnesium, copper, manganese, molybdenum, selenium and cobalt. Examples of metal oxides that can be used in the invention include oxide of iron, zinc, copper, manganese, molybdenum, selenium and cobalt. With the metal oxides, however, an acid may need to be used as a processing aid. Examples of metal carbonates that can be used include calcium and magnesium carbonate. Examples of metal chlorides that can be used in the invention include calcium and magnesium chloride. In one aspect of the invention, calcium chloride is used as the mineral source. Examples of metal borates that can be used include sodium tetraborate, sodium borate, calcium borate, and various hydrated forms or derivatives of these borates.

[0026] The process for making the mineral amino acid chelate compounds is carried out for a time and under operating conditions sufficient to substantially complete the reaction. In one aspect of the invention, the reaction is carried out until the desired chelate compound is completed. In another aspect of the invention, however, the reaction is carried out only until the desired complex is completed. The reaction process can be aided by any known mixing (i.e., stirring) process.

[0027] The time for the reaction process will depend on the desired degree of completion of the reaction. Generally, the time for the reaction can range from about 0 to about 60 minutes. In one aspect of the invention, the time for the reaction can range from about 1 to about 24 hours.

[0028] The temperature for the reaction process will also depend on the desired degree of completion of the reaction. The temperature for the reaction can range from about 25 to about 80 degrees.

[0029] When the reaction is complete, the foliar fertilizer is in a liquid form, i.e., in solution. In one aspect of the invention, the foliar fertilizer solution is then dried into a powder using any suitable drying process. Any drying process known in the art can be used, including oven drying, drum drying, fluidized granulation, other commercially viable drying methods, or combinations thereof. In one aspect of the invention, the drying processes used in the invention comprises spray-drying.

[0030] If desired, the powder can be converted into another solid form like a tablet, capsule, granule or the like by any known process in the art. Conversion into these solid forms is especially useful where the amino acid chelate will be used other than as a fertilizer.

[0031] There are several advantages to having the foliar fertilizer compositions of the invention in a solid form. First, they are light for shipping and therefore economical. Second, there exists little to no precipitation of the chelate compound out of solution during shipping or long periods of storage. Third, since they are dry, there is little or no need for preservatives or anti-microbial agents.

[0032] The amino acid chelate compounds of the invention have many possible uses. First, they may be used as plant foliar fertilizers and nutrients as described above. For such uses, the composition can be dissolved for use on leaves or other parts of the plant, or it can be used directly as a soil treatment. Second, the compounds can also be dry blended in combination with other metal salts and/or a variety of ligands for more unique applications. Third, these chelates and complexes can also be used in animal feeds by any method currently known in the art. And fourth, some of the compounds can be used in food applications, in pharmaceuticals, and/or nutritional supplements for crustaceans, reptiles and warm-blooded animals, including humans.

[0033] The foliar fertilizers of the invention and the methods of making and using such foliar fertilizers are exemplified in the following examples.

EXAMPLE 1

[0034] 282 lbs of calcium chloride didrate was obtained. 287 lbs of non-synthetic amino acids were obtained from soybeans in the following manner. The soybeans are first ground into a powder. The powder was then suspended in water and subjected to hydrolysis. The resulting liquid was then mechanically filtered in a filter press to remove the solid materials. The liquid was then dried in a spray dried until a powder was obtained.

[0035] These two components (calcium chloride didrate and non-synthetic amino acids) were mixed in an aqueous solution and reacted until the chelation was complete and then spray dried until a powder was obtained. The chelated composition contained 56 wt % of the calcium chloride hexahydrate and 44 wt % of the non-synthetic amino acids. The chelated composition contained just these two components.

EXAMPLE 2

[0036] A zinc amino acid chelate composition was prepared similar to the process described in Example 1, except that zinc 804 was used in place of calcium chloride hexahydrate. The resulting product contained 20 wt % zinc.

[0037] 80 grams of actual zinc in the zinc amino acid chelate applied per acre was selected as the standard (or 1×) rate. The amount of the dry product necessary to apply this standard rate was then calculated. Applications were then made to canning beans at the following rate: 0.2×, 0.4×, 0.6×, 1×, 1×, 2×, 3×, 4×, 6×, and 8×. Plant tissue samples were then taken 7 days following the application.

[0038] There was no burn observed on any plants at any of the rates applied. A summary of the plant tissue analysis is depicted in **FIG. 2**. As shown in **FIG. 2**, there was a nice dose versus response trend.

EXAMPLE 3

[0039] A calcium amino acid chelate composition was prepared similar to the process described in Example 1, except that calcium was used in place of calcium chloride hexahydrate. The resulting product contained 17.8 wt % calcium.

[0040] 60 grams of actual calcium in the calcium amino acid chelate applied per acre was selected as the standard (or 1×) rate. The amount of the dry product necessary to apply this standard rate was then calculated. Applications were then made to canning beans at the following rates: 1×, 2×, 3×, 4×, 5×, 6×, 7×, and 8×. Plant tissue samples were then taken 5 days following the application.

[0041] There was no burn observed on any plants at any of the rates applied. A summary of the plant tissue analysis is depicted in **FIG. 3**.

EXAMPLE 4

[0042] A calcium amino acid chelate composition was prepared similar to the process described in Example 1, except that calcium acetate was used in place of calcium. The resulting product contained 0 wt % calcium.

[0043] 60 grams of actual calcium in the calcium amino acid chelate applied per acre was selected as the standard or 1× rate. The amount of the dry product necessary to apply this standard rate was then calculated. Applications to made to canning beans at the following rates: 1×, 2×, 4×, and 8×. Plant tissue samples were then taken 5 days following the application.

[0044] A summary of the plant tissue analysis is depicted in **FIG. 4**. **FIG. 4** also compared the results of Example 3 with this example (Example 4). Both of these results were compared with a non-organic approved calcium amino acid chelate sold as Metalosalate® calcium.

EXAMPLE 5

[0045] Several batches of foliar fertilizer compositions were made in the following manner using the information in Table 1. The reported amount of hot tap water was provided in a container. The reported amount of a mineral source was then added to the water and the mixture was stirred. The reported amount of CVP LS-hydrolyzed soy protein (9.46 wt % N, 0.857 wt % Mg, and 2.39 wt % Ca) as a chelating agent was then added and the mixture was stirred until the chelating agent was completely dissolved and there were no lumps present. The mixture was then spray dried until a powder was obtained and the amount of mineral in the powder was measured.

TABLE 1

Foliar Fertilizer	Water (lbs)	Mineral Source	Mineral Source (lbs)	Chelating Agent (lbs)	Wt % Mineral
Manganese Organic Powder	171.72	Manganese Sulfate (31 wt % Mn)	529.81	470.19	16.4
Magnesium Organic Powder	159.09	Magnesium sulfate (9.8 wt % Mg)	796.98	484.97	6.5
Iron Organic Powder	159.65	Ferrous Sulfate (20 wt % Fe)	807.90	435.84	15
Copper Organic Powder	171.70	Copper Sulfate (25 wt % Cu)	760.87	457.06	16
Calcium Organic Powder	159.92	Calcium Chloride (26 wt % Ca)	494.98	505.02	12.9
Zinc Organic Powder	175.05	Zinc Sulfate (35.5 wt % Zn)	544.72	455.28	19.3

[0046] Having described the preferred aspects of the invention, it is understood that the invention defined by the appended claims is not to be limited by particular details set forth in the above description, as many apparent variations thereof are possible without departing from the spirit or scope thereof.

What is claimed is:

1. An amino acid chelate composition containing less than a negligible amount of at least one of wetting agents, anti-foaming agents, anti-microbial agents, preservatives, and similar additives.

2. The composition of claim 1, wherein the negligible amount is 0.1 wt %.

3. The composition of claim 1, wherein the composition contains only trace amounts of wetting agents, anti-foaming agents, anti-microbial agents, preservatives, and similar additives.

4. The composition of claim 1, wherein the composition contains only a negligible amount of a wetting agent.

5. The composition of claim 1, wherein the composition contains only a negligible amount of an anti-foaming agent.

6. The composition of claim 1, wherein the composition contains only a negligible amount of an anti-microbial agents.

7. The composition of claim 1, wherein the composition contains only a negligible amount of a preservative.

8. The composition of claim 1, wherein the composition contains no wetting agents, anti-foaming agents, anti-microbial agents, preservatives, and similar additives.

9. The composition of claim 1, wherein the composition is in a solid form.

10. A foliar fertilizer comprising an amino acid chelate composition and negligible amounts of at least one of wetting agents, anti-foaming agents, anti-microbial agents, preservatives, and similar additives.

11. The fertilizer of claim 10, wherein the negligible amount is 0.1 wt %.

12. The fertilizer of claim 10, wherein the composition contains only trace amounts of wetting agents, anti-foaming agents, anti-microbial agents, preservatives, and similar additives.

13. The fertilizer of claim 10, wherein the composition contains no wetting agents, anti-foaming agents, anti-microbial agents, preservatives, and similar additives.

14. A nutrient system comprising a foliar fertilizer containing an amino acid chelate composition and negligible amounts of at least one of wetting agents, anti-foaming agents, anti-microbial agents, preservatives, and similar additives.

15. An organic approved amino acid chelate composition.

16. A foliar fertilizer consisting essentially of an amino acid chelate composition.

17. A method for making an amino acid chelate composition, comprising:

providing a organic-approved mineral source;

providing a chelating agent; and

mixing these components together in an aqueous solution.

18. The method of claim 17, wherein the organic-approved mineral source comprises elemental metals, metal sulfates, metal oxides, metal carbonates, metal chlorides, metal borates, and combinations thereof.

19. The method of claim 17, wherein the chelating agent comprises hydrolyzed vegetable protein.

20. The method of claim 17, further including drying the mixture.

21. A method for making an amino acid chelate composition, comprising mixing a organic-approved mineral source and a chelating agent in an aqueous solution while

using negligible amounts of at least one of wetting agents, anti-foaming agents, anti-microbial agents, preservatives, and similar additives.

22. The method of claim 21, wherein the negligible amount is 0.1 wt %.

23. The method of claim 21, comprising only trace amounts of wetting agents, anti-foaming agents, anti-microbial agents, preservatives, and similar additives.

24. The method of claim 21, comprising using no wetting agents, anti-foaming agents, anti-microbial agents, preservatives, and similar additives.

25. A method of fertilization, comprising:

providing an amino acid chelate composition containing less than a negligible amount of at least one of wetting agents, anti-foaming agents, anti-microbial agents, preservatives, and similar additives; and

applying the composition to the leaves of plants or to the soil.

26. A method of providing nutrition, comprising:

providing an amino acid chelate composition containing less than a negligible amount of at least one of wetting agents, anti-foaming agents, anti-microbial agents, preservatives, and similar additives; and

administering the composition to an animal or human.

* * * * *

EXHIBIT B

US005298482A

United States Patent [19]

Tanaka et al.

[11] Patent Number: 5,298,482

[45] Date of Patent: Mar. 29, 1994

[54] **METHOD FOR PROMOTING PLANT GROWTH USING 5-AMINOLEVULINIC ACID OR A SALT THEREOF**

[75] Inventors: **Tohru Tanaka; Kiyoshi Takahashi; Yasushi Hotta,** all of Saitama; **Yasutomo Takeuchi; Makoto Konnai,** both of Tochigi, all of Japan

[73] Assignee: **Cosmo Research Institute,** Tokyo, Japan

[21] Appl. No.: **881,705**

[22] Filed: **May 12, 1992**

[30] **Foreign Application Priority Data**

May 14, 1991 [JP] Japan 3-107987

[51] **Int. Cl.**[5] **A01N 37/44**

[52] **U.S. Cl.** **504/320;** 504/147; 504/129; 504/130; 504/142; 504/140

[58] **Field of Search** 71/113, 77; 504/320, 504/147, 129, 130, 142, 140

[56] **References Cited**

U.S. PATENT DOCUMENTS

2,395,446 2/1946 Benson 71/113

FOREIGN PATENT DOCUMENTS

8600785 2/1986 PCT Int'l Appl. .
9011013 10/1990 PCT Int'l Appl. .

OTHER PUBLICATIONS

Adamson et al, CA 103: 120098e, "Light Independent Accumulation of Chlorophyll . . . ", p. 431 (1985), (Abstract Only).

Shlyk et al, CA 84: 69771d, "Effect of 5-Amionlevulinic Acid on the Accumulation . . . ", (1976), (Abstract Only).

Chemical Abstracts, vol. 81, No. 5, Abstract No. 22178P Aug. 5, 1974.

Derwent Abstract of JP-A-01 148 193, Section Ch, AN 89-210659/29, Sep. 13, 1989.

Chemical Abstracts, vol. 78, No. 5, Abstract No. 24609S, Feb. 5, 1973.

Biological Abstracts, vol. 89, No. 1, Abstract No. 8458, Jan. 1, 1990.

Chemical Abstracts, vol. 108, No. 9, Abstract No. 70580M, Feb. 29, 1988.

Chemical Abstracts, vol. 114, No. 11, Abstract No. 98450S, Mar. 18, 1991.

Biological Abstracts, vol. 65, Abstract No. 4597 Jan. 1, 1978.

Biological Abstracts, vol. 77, No. 4, Abstract No. 30758, 1984.

Primary Examiner—Allen J. Robinson
Assistant Examiner—B. Bembenick
Attorney, Agent, or Firm—Sughrue, Mion, Zinn, Macpeak & Seas

[57] **ABSTRACT**

A method for treating plants with a plant growth promoter comprising 5-aminolevulinic acid or a salt thereof as an active ingredient. This treatment method is effective in enhancing the photosynthetic activity of a plant, enhancing its ability to absorb CO_2, suppressing its respiration, increasing its chlorophyll content and promoting its growth. As a result, the treatment greatly contributes to the promotion of rooting, the reduction of lodging, an increase in yield, an improvement in cold resistance, maintenance of freshness, an improvement and maintenance of green color, the growth of good seedlings, the promotion of organs, an increase in tillers, a shortening of the time required for growth, a relief of chemical damage and an increase in the rooting ratio in, for example, cutting.

29 Claims, No Drawings

METHOD FOR PROMOTING PLANT GROWTH USING 5-AMINOLEVULINIC ACID OR A SALT THEREOF

FIELD OF THE INVENTION

This invention relates to a method for promoting plant growth. More particularly, it relates to a novel method for promoting plant growth which is effective in, for example, promoting rooting, reducing lodging, increasing yield, improving cold resistance, maintaining freshness, improving and maintaining green color, growing good seedlings, promoting the growth of organs, increasing the number of tillers, shortening the growth period, relieving chemical damage and increasing the rooting ratio in cutting.

BACKGROUND OF THE INVENTION

A number of attempts have been made in order to improve the yield of plants. Among them, studies on plant growth regulators have been rapidly developed in recent years since plant hormones, which are physiologically active substances in common to all plants, were discovered. Six plant hormones, namely, gibberellin, auxin, cytokinin, ethylene, abscisic acid and brassinolide are known at present.

However these plant hormones mainly affect only a part of a plant organ. For example, indoleactic acid promotes rooting, gibberellin is usable in the formation of seedless grapes, ethephon promotes maturing of fruits and maleic hydrazide is usable as a sucker inhibitor for tobacco. Thus, none of them affects the whole plant or increases its yield.

On the other hand, chemicals improving the photosynthetic capability of a plant have attracted public attention since they affect the whole plant and thus increase its yield. For example, it has been found that N-allyl-N-methylglycine and N,N-dimethylglycine improve the photosynthetic capability in cultured cells (refer to Proceedings of Society of Plant Chemical Regulation in 1990). It is known, further, that choline chloride and its derivatives improve photosynthetic capability, though this function is still unsatisfactory.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a method for promoting plant growth whereby the whole plant is affected and thus, for example, its yield is increased.

Under these circumstances, the present inventors have conducted extensive studies and, as a result, found out that 5-aminolevulinic acid or its salts, the herbicidal and insecticidal actions of which have been known (refer to JP-W-61-502814 and JP-A-2-138201, the term "JP-W" as used herein means an "unexamined published Japanese international patent application" and the term "JP-A" as used herein means an "unexamined published Japanese patent application"), are unexpectedly effective in improving photosynthetic capability, suppressing respiration, improving CO_2 absorbing ability, increasing the chlorophyll content and promoting the growth of plants, thus achieving the above-mentioned object.

Accordingly, the present invention provides a method for promoting plant growth which comprises applying 5-aminolevulinic acid or its salt, as an active ingredient, in an effective dose to a plant to thereby achieve the effects later discussed.

DETAILED DESCRIPTION OF THE INVENTION

It is known that 5-aminolevulinic acid or its salts used in the present invention are useful as herbicides and insecticides. However it has never been reported hitherto that these compounds have a function of promoting plant growth.

5-aminolevulinic acid or its salts are known compounds and can be obtained through, for example, chemical synthesis, production by microorganisms or enzymatic production. When these compounds are produced using microorganisms or enzymes, the obtained products can be used as such without separating or purifying, so long as they are free from substances toxic to plants.

Examples of the salts of 5-aminolevulinic acid include acid addition salts such as the hydrochloride, phosphate, nitrate, sulfate, acetate, propionate, butyrate, valerate, citrate, fumarate, maleate and malate salts as well as metal salts such as the sodium salt, potassium salt and calcium salt.

These salts are employed in the form of an aqueous solution at use and thus exert the same effects as those achieved by using 5-aminolevulinic acid. Either 5-aminolevulinic acid or its salts or a mixture thereof may be used. Since 5-amionolevulinic acid or its salts is easily soluble in water, the concentration of the aqueous 5-aminolevulinic acid solution can be freely selected depending on the purpose of its actual use.

The treatment agent to be used in the method for promoting plant growth according to the present invention, which will be referred to as "the invention agent" hereinafter, may comprise 5-aminolevulinic acid or its salt alone. Alternately, it may comprise other plant growth regulators, sugars, amino acids, organic acids, alcohols, vitamins, minerals and others. Examples of the plant growth regulators usable here include brassinolides such as epibrassinolides, cholines such as choline chloride and choline nitrate, indolebutyric acid preparations, indoleacetic acid preparations, ethychlozate preparations, 1-naphthylamide preparations, isoprothiolane preparations, nicotinic acid amide preparations, hydroxyisoxasole preparations, calcium peroxide preparations, benzylaminopurine preparations, methasulfocarb preparations, oxyethylene docosanol preparations, ethephon preparations, cloxyfonac preparations, gibberellin, streptomycin preparations, daminozide preparations, 4-CPA preparations, ancymidol preparations, inabenfide preparations, uniconazole preparations, chlormequat preparations, dikegulac preparations, daminozide preparations, mefluidide preparations, calcium carbonate preparations and piperonyl butoxide preparations. Among them, brassinolides, cholines, isoprothiolane preparations, and hydroxyisoxasole preparations are preferred.

Examples of the sugars usable here include glucose, sucrose, xylitol, sorbitol, galactose, xylose, mannose, arabinose, madulose, ribose, rhamnose, fructose, maltose, lactose and maltotriose. Among them, glucose, sucrose, and galactose are preferred.

Examples of the amino acids usable here include asparagine, glutamine, histidine, tyrosine, glycine, arginine, alanine, tryptophan, methionine, valine, proline, leucine, lysine and isoleucine.

Examples of the organic acids usable here include formic acid, acetic acid, propionic acid, butyric acid, valeric acid, oxalic acid, phthalic acid, benzoic acid, lactic acid, citric acid, tartaric acid, malonic acid, malic acid, succinic acid, glycolic acid, glutamic acid, aspartic acid, maleic acid, caproic acid, caprylic acid, myristic acid, stearic acid, palmitic acid, pyruvic acid, α-ketoglutaric acid and levulinic acid. Among them, acetic acid, propionic acid, malic acid, succinic acid, glutamic acid, and levulinic acid are preferred.

Examples of the alcohols usable herein include methanol, ethanol, propanol, butanol, pentanol, hexanol and glycerol with methanol and ethanol being preferred.

Examples of the vitamins usable herein include nicotinic acid amide, vitamin B_6, vitamin B_{12}, vitamin B_5, vitamin C, vitamin B_{13}, vitamin B_1, vitamin B_3, vitamin B_2, vitamin K_3, vitamin A, vitamin D_2, vitamin D_3, vitamin K_1, α-tocopherol, β-tocopherol, γ-tocopherol, δ-tocopherol, p-hydroxybenzoic acid, biotin, folic acid, nicotinic acid, pantothenic acid and α-liponic acid.

Examples of the minerals usable here include nitrogen, phosphorus, potassium, boron, manganese, zinc, copper, iron, molybdenum and magnesium.

The agent to be used in the method for promoting plant growth of the present invention may be in the form of, for example, powder, granules or liquid. These formulations may be produced by a conventional method with the use of, for example, solvents, dispersion media or extenders.

The agent to be used in the method for promoting plant growth of the present invention may be in the form of either a foliage treatment agent or a soil treatment agent. Alternately, it may be absorbed by plants before planting or cutting (i.e., a soaking treatment agent). Alternately, it may be added to water for hydroponic use.

When the agent of the invention is used in foliage treatment, it preferably contains from 1 to 1,000 ppm, still preferably from 10 to 500 ppm, more preferably from 10 to 250 ppm, of 5-aminolevulinic acid or its salt and is applied in an amount of from 10 to 1,000 l, still preferably from 50 to 300 l, per 10 a ("a" means the area of 100 m^2). When this agent is to be applied to a plant on the leaves of which chemicals would hardly stick (for example, monocotyledon), it is desirable to further use a spreader (for example, anionic, cationic or nonionic surfactants) therewith. The type and amount of the spreader are not particularly restricted.

When the agent of the invention is used in soil treatment, it is preferably applied in an amount of from 1 to 1,000 g, still preferably from 10 to 500 g, of 5-aminolevulinic acid or its salt per 10 a. In the case of hydroponics, the agent may be used at essentially the same amount.

When the agent of the invention is used in soaking treatment whereby 5-aminolevulinic acid or its salt is absorbed by a plant before planting, the concentration of 5-aminolevulinic acid or its salt in the soaking solution preferably ranges from 0.001 to 10 ppm, still preferably from 0.01 to 5 ppm. The soaking may be carried out for 1 hour to 1 week, preferably for 3 hours to 1 day at ambient.

Although each of these treatments may be performed at any stage of the growth of a plant, it is particularly effective to perform the treatment at the seedling stage or the grain maturing stage. A single application can achieve satisfactory results. However the results can be further improved by repeating the application. When the application is to be performed twice or more, the treatment methods as described above may be appropriately combined with each other, if required. When the agent of the invention is used together with other chemicals or fertilizers in order to facilitate the application, it may be mixed with any materials so long as the effects thereof are not deteriorated thereby.

The plants to be treated with the agent of the invention are not particularly restricted. Examples thereof include cereals such as rice, barley, wheat, corn, barnyard millet and foxtail millet; vegetables such as pumpkin, turnip, cabbage, radish, Chinese cabbage, spinach, pimento and tomato; fruit trees such as orange, apple, persimmon, Japanese apricot, pear, grape and peach; flowers such as chrysanthemum, Transvaal daisy, pansy, orchid, peony and tulip; trees such as azalea, oak (*Quercus acutissima*), Japanese cedar, white cedar, Japanese oak and beech; beans such as adzuki bean, kidney bean, soybean, peanut, broad bean and pea; lawn grasses such as Korean lawn grass, bent grass and field grass; potatoes such as potato, sweet potato, Japanese taro, yam and taro; onions such as Welsh onion, onion and scallion; and pasture grasses such as alfalfa, clover and Chinese milk vetch.

The agent of the invention can be applied for, e.g., promoting rooting, reducing lodging, increasing yield, improving cold resistance, maintaining freshness, improving and maintaining green color, growing good seedlings (having thick stemmed, well colored, well rooted, but before much growth), promoting the growth of organs (e.g., root, stem, leaf, callus, shoot primordium, hairly root), increasing number of tillers, shortening the plant growth period, relieving chemical damage and increasing the rooting ratio (a ratio of the number of active rootings to the number of total treated rootings) in cutting, herbaceous cutting, foliate cutting, fix planting of seedlings, transplanting and grafting.

Next, the methods for using the agent of the invention depending on purposes and plants to be treated therewith will be described in detail.

When the agent of the invention is to be used in order to promote rooting of plants, it may be applied either by the foliage treatment, the soil treatment or by the soaking treatment, each as described above. The agent of the invention is characterized in that it can promote rooting even by the foliage treatment. In order to promote rooting, the invention agent is applicable to any plant having roots. Particularly preferable examples of plants to be treated therewith include Japanese cedar, white cedar, tea plant, mulberry, Japanese holly, seseli, kinpouju, rhododendron, doudantsutsuji (*Enkianthus perulatus*), Himalayan cedar, carnation, chrysanthemum, tulip, lawn grass, rice, camellia, mametsuge (*Buxus microphylla*), sweet osmanthus, metasequoia, spindle tree, aucuba, daphne, geranium, tobacco, dahlia, rose, orchid, pine tree, maple tree, oak, eggplant, cucumber, tomato, lettuce and cabbage. It is particularly desirable to apply the invention agent in the growth stages (for example, seedling stage) of plants, though the application time is not restricted thereto.

In order to increase the rooting ratio of plants, the invention agent may be applied either by the soil treatment, the foliage treatment or the soaking treatment, each as described above. Examples of plants to be treated with the invention agent for this purpose include seedlings of Japanese cedar, tea, rice, white cedar, pine, eggplant, cucumber, cabbage, chrysanthemum and sweet potato.

In order to grow good seedlings, the invention agent may be applied either by the soil treatment, the foliage treatment or the soaking treatment, each as described above. It is also possible to soak seeds in a solution of the invention agent (soaking treatment). The concentration of the invention agent in this soaking treatment and the soaking time may be determined in accordance with the conditions selected for soaking seedlings. Examples of plants to be treated with the invention agent for this purpose include rice, Japanese cedar, tea, white cedar, pine, eggplant, cucumber, cabbage, pimento, green pepper, okra and corn. When the invention agent is used for growing good seedlings, it may be employed together with other agents for this purpose. Examples of the other agents include isoprothiolane preparations, calcium peroxide preparations, nicotinic acid amide preparations, hydroxyisoxazole preparations, benzylaminopurine preparations and methasulfocarb preparations.

In order to reduce lodging of plants, the invention agent may be used by any method without restriction. When it is applied in the growth stage of a plant, the roots and stem of the plant grow well and, therefore, lodging can be effectively reduced in particular. Many plant growth regulators would promote the growth of plants but simultaneously cause spindly growth thereof. In contrast, the invention agent never cause any undesired spindly growth. Although the invention agent exerts satisfactory effects when used alone, these effects can be further enhanced by combining it together with an agent capable of controlling inter-node growth of plants. Examples of the agent to be combined therewith include ancymidol preparations, inabenfide preparations, uniconazole preparations, chlormequat preparations, dikegulac preparations, daminozide preparations and mefluidide preparations. Examples of plants to be treated with the invention agent for this purpose include chrysanthemum, lily, poinsettia, tulip, rice, rhododendron, rosebay, wheat, hibiscus, barley, Japanese holly, seseli, cherry tree, ibotanoki (*Ligustrum obtusifolium*), abelia and corn.

In order to increase the yield of the whole or a part of a plant, the invention agent may be used by any method and at any stage without restriction. It is particularly preferable to apply the invention agent at the early grain maturing stage. More concretely, it is particularly effective to apply the invention agent to cereals (for example, rice or wheat) before or during the blooming stage, to onions (for example, onion or garlic) at the bulb formation stage, to potatoes (for example, sweet potato or potato) at the potato formation stage, to cabbage and lettuce at the early head formation stage, and to spinach and komatsuna (*Brassica Rapa* var. *pervidis*) at the early growth stage. The invention agent is effective for increasing the yield of every plant. Namely, it is characterized by being widely applicable to, for example, cereals, potatoes, onions, beans, vegetables and fruits. In particular, the invention agent may be preferably used to increase the yields of rice, barley, wheat, sweet potato, potato, soybean, adzuki bean, kidney bean, Japanese taro, yam, onion, Welsh onion, garlic, cabbage, spinach, lettuce, komatsuna, peach, persimmon, grape, fig, kiwi, apple, banana, pineapple, tomato, eggplant, pimento, green pepper, okra, pumpkin, strawberry, asparagus, radish, carrot, broccoli, cauliflower, burdock and lotus root. Furthermore, the invention agent may be combined with, for example, cholines or brassinolides.

In order to improve the cold resistance of plants, though the invention agent may be used by any method and at any stage without restriction, it is preferred to use at the growth stage. The application of the invention agent makes it possible to enrich a plant, to improve its cold resistance and thus to accelerate the recovery of the plant from cold summer damage. Examples of plants to be preferably treated with the invention agent in order to improve cold resistance include rice, barley, wheat, corn, spinach, komatsuna, lettuce, cabbage lettuce and cabbage.

In order to maintain the freshness of plants, the invention agent may be applied either before or after harvesting. For pre-harvest application, either foliage treatment or soil treatment may be selected. It is preferable to perform the treatment within 2 weeks, still preferably within 1 week, before harvesting. As post-harvest application, foliage treatment is mainly selected. In the case of cut flowers or soaking treatment, the above-mentioned soaking treatment may be performed. This treatment is more suitable for vegetables and cut flowers, rather than fruits. Examples of plants to be treated for this purpose, include spinach, komatsuna, rape, field pea, leek, nozawana, hop, lettuce, cabbage lettuce, cabbage, broccoli, cauliflower, pimento, Welsh onion, kidney bean, chrysanthemum, carnation, freesia, Transvaal daisy, kinpouju, stock, lily, gentian and hyacinth.

In order to improve and maintain the green color of plants, the invention agent may be applied by any method and at any stage without restriction. It may be applied not only during the growth of plants but also to harvested plants. As the post-harvest application, foliage treatment is mainly selected. In the case of cut flowers or soaking treatment, the above-mentioned soaking treatment may be performed. Examples of plants to be treated therewith for this purpose include hepatica, lawn grass, spinach, komatsuna, rape, field pea, leek, hop, lettuce, cabbage lettuce, cabbage, broccoli, pimento, Welsh onion, kidney bean, chrysanthemum, carnation, freesia, Transvaal daisy, adiantum, Chinese cabbage, orchid, pothos, horutonoki (*Elaeocarpus decipiens*), agave and aloe.

In order to relieve chemical damage, the invention agent may be applied by any method at any stage without restriction. However it is recommended to apply the agent before the application of chemicals causing the damage. The invention agent is effective in promoting the whole plant and to improve its vitality so as to relieve all chemical damage. In particular, it is effective in relieving chemical damage caused by herbicides of the photosynthesis-inhibition type. In this case, it is sometimes observed that the treatment with the invention agent, even if performed after the application of the herbicide causing the chemical damage, promotes recovery. Examples of herbicides of this type include pyrazolate preparations, dimethazone preparations, chlorphthalim preparations, oxadiazone preparations, phthalimide preparations, fluridone preparations, dicyanomalelonitrile preparations, carbamate preparations, urea preparations and triazine preparations. In addition, the invention agent is highly effective in relieving chemical damage caused by organic phosphoric acid insecticides (e.g., diazinon, sulprofos) and carbamate insecticides (e.g. 1-naphtylmethylcarbamate, methomyl).

In order to increase the number of tillers, the invention agent may be applied by any method at any stage without restriction. Namely, it is usable in seed treat-

ment (soaking treatment), soil treatment or foliage or soil treatment after planting. Examples of plants to be preferably treated therewith for this purpose include cereals such as rice and barley.

In order to shorten the growth time of plants, the invention agent may be applied by any method at any stage without restriction. Namely, it is usable either in soil treatment, foliate treatment or soaking treatment. Examples of plants preferably treated therewith for this purpose include cereals such as rice and barley, various vegetables and fruit trees. In particular, the growth time of plants frequently suffering from cold summer damage can be shortened by using the invention agent and, as a result, cold summer damage can be prevented.

In order to promote the growth of organs, it is preferable to add the invention agent to a medium (for example, a Murashige-Skoog medium, a Linsmaier-Skoog medium) during the incubation of said organ. Similar to the above-mentioned soaking treatment, the concentration of the invenlion agent preferably ranges from 0.001 to 10 ppm, still preferably from 0.01 to 5 ppm, and the incubation may be performed at 20° to 30° C., preferably 25° C. for from 1 hour to 1 week, preferably from 3 hours to 1 day. Other conditions (e.g., quantity of light, amount of airflow) are dependent on a plant. Examples of the organ include callus, shoot primordium, hairly root, stem, hypocotyl, root, and pollen.

Although the function mechanism of the agent used in the method for promoting plant growth of the present invention has never been clarified in detail, it is assumed that the photosynthetic activity and CO_2 absorption capability are enhanced, respiration is suppressed and the chlorophyll content is increased. That is to say, the application of the invention agent: (1) enhances photosynthetic activity; (2) increases chlorophyll content; and (3) enhances CO_2 absorption capability. The photosynthetic activity is determined by the CO_2 fixing amount by photosynthesis of a plant. The chlorophyll content is a total amount of the chlorophyll of a reaction center and the light collective chlorophyll. The CO_2 absorption capability is determined by the difference in CO_2 absorption amount of photosynthesis and breathing of a plant. A plant fixes CO_2 by photosynthesis while metabolizing the photosynthetic products by respiration, thus liberating CO_2. When the invention agent is applied to the plant, respiration is suppressed and thus the accumulation of the photosynthetic products is accelerated. The amount of respiration is the CO_2 amount by respiration of a plant. It is therefore considered that the growth of the plant is promoted through the above-mentioned three functions.

When applied to plants, 5-aminolevulinic acid or its salt would enhance the photosynthetic activity and the CO_2 absorption capability, suppress the respiration and increase the chlorophyll content. Thus the method of the present invention is highly effective in, for example, promoting rooting, reducing lodging, increasing yield, improving cold resistance, maintaining freshness, improving and maintaining green color, growing good seedlings, promoting the growth of organs, increasing the number of tillers, shortening the growth period, relieving chemical damage and increasing the rooting ratio in cutting.

To further illustrate the present invention in greater detail, and not by way of limitation, the following Examples will be given. Unless otherwise indicated, all Examples were conducted at room temperature. In addition, % is indicated by % by weight based on the total solution amount.

EXAMPLE 1

Cucumber (aonaga-jibae) seeds were pasteurized by soaking in a 2% solution of sodium hypochlorite for 10 minutes and then allowed to absorb water by washing under running water for 4 hours. Next, these seeds were sowed on moistened vermiculite and grown at 25° C. under a daylight fluorescent lamp of 6,000 lux for 6 days. The sprouts thus obtained were harvested. Then a piece was cut from each sprout 5 mm below the cotyledon nod. Six pieces were each introduced into distilled water and 1 ppm and 3 ppm aqueous solutions of 5-aminolevulinic acid (hereinafter simply referred to as 5-ALA) and incubated at 25° C. under irradiation at 6,000 lux for 20 hours. Then the length of each piece was measured. Further, the green color of each piece was evaluated in 5 grades, 1, 2, 3, 4, 5 referring to the color of the control lot (distilled water) as 3, with the naked eye. The more number means thicker green and good results. Table 1 summarizes the averages.

TABLE 1

5-ALA conc.	0 ppm	1 ppm	3 ppm
Average (length: mm)	5.62	5.84	5.96
Standard deviation	0.17	0.22	0.42
Green color	3	5	4

As the above results clearly show, the addition of 5-ALA promoted the growth and improved green color.

EXAMPLE 2

Young rice (sasanishiki) seedlings of about 8 cm in above-ground length, which had been grown in a seedling-raising box, were cut in such a manner as to give an above-ground length of 5 mm and sowed in high-wall Petri dishes in such a manner that each dish had 10 seeds. Then a 5-ALA aqueous solution or a control was added to each dish so as to give a depth of 1 cm and the seedlings were grown at 25° C. under 6,000 lux for 8 days. Next, the length of regenerated leaves and the total weight thereof were measured.

Table 2 shows the average data of 10 seeds.

TABLE 2

5-ALA conc.	Leaf length (cm)	Total weight (mg)
0 ppm	4.1	49.4
1 ppm	6.8	64.3

As Table 2 clearly shows, the addition of 5-ALA promoted the growth of the regenerated leaves.

EXAMPLE 3

Young rice (sasanishiki) seedlings of about 3 cm in above-ground length, which had been grown in a seedling-raising box, were soaked in 0 ppm, 1 ppm and 3 ppm 5-ALA aqueous solutions for 1, 6, 9, 24 and 48 hours (each lot having 8 seedlings). After washing with water, these seedlings were transplanted into paddy field pots and grown in a greenhouse for 2 weeks. Then the seedlings were pulled out and the above-ground length, total weight after removing the husk, and the number of roots of each seedling were determined and the average data were calculated. Tables 3, 4 and 5 show the results.

TABLE 3

5-ALA conc. (ppm)	Above-ground length (cm/seedling) Soaking time 1 hr	6 hr	9 hr	24 hr	48 hr
0	4.85	5.39	6.08	5.06	5.34
1	5.57	6.87	6.10	6.64	4.70
3	6.00	7.88	5.62	7.24	6.27

TABLE 4

5-ALA conc. (ppm)	Total weight (mg/seedling) Soaking time 1 hr	6 hr	9 hr	24 hr	48 hr
0	21.9	34.3	32.2	28.8	26.6
1	38.9	54.3	47.6	50.4	36.6
3	45.4	50.8	35.3	50.8	44.7

TABLE 5

5-ALA conc. (ppm)	No. of roots (/seedling) Soaking time 1 hr	6 hr	9 hr	24 hr	48 hr
0	3.4	4.1	2.5	3.4	3.7
1	4.5	7.0	4.8	6.2	4.2
3	5.4	7.2	5.4	6.6	6.4

As the above Tables 3, 4 and 5 clearly show, the treatment with the invention agent was effective in promoting the growth and the rooting, increasing the rooting ratio of rice and growing good seedlings.

EXAMPLE 4

Rice seeds (akinishiki) were pasteurized and sprouted in a conventional manner. Then seeds of uniform size were selected and sowed with a pair of tweezers on expanded polyethylene sheets channeled with a cutter at a ratio of 10 seeds per sheet. Next, these sheets were floated in high-wall Petri dishes filled with 150 ml portions of 5-ALA aqueous solutions of various concentrations. After growing at 28° C. under 5,000 lux for 7 days, the above-ground length, the longest root and the number of roots of each seedling were determined. Table 6 shows the average values of 10 seeds.

TABLE 6

5-ALA conc. (ppm)	Above-ground length (cm)	Longest root (cm)	No. of Roots
0	6.4	6.8	4.2
0.01	7.5	8.3	6.2
0.03	7.9	7.0	8.7
0.1	7.8	7.5	5.5
0.3	6.7	7.3	4.8

As Table 6 clearly shows, the addition of 5-ALA resulted in the elongation of the above-ground length and the root length and increased the number of roots, which indicated that rooting was promoted and good seedlings were grown.

EXAMPLE 5

Rice seedlings (akinishiki, above-ground length: about 5 cm) grown in a seedling-raising box were cut so as to leave 5 mm of roots. Then these seedlings were introduced into flat-bottomed test tubes containing 50 ml portions of 5-ALA aqueous solutions of various concentrations and fixed with cotton plugs in such a manner that the roots came in contact with the solutions. 12 test tubes were prepared for each concentration and classified into two groups. The seedlings of one group were grown at 28° C., under irradiation at 5,000 lux for 24 hours, for 7 days [Condition A]. The test tubes of the other group were coated with an aluminum foil so as to shade the roots and the seedlings were grown, under a cyclic system of 28° C. at 5,000 lux for 12 hours and at 23° C. in the dark for 12 hours, for 7 days [Condition B]. After 7 days, the seedlings were taken out and the roots were cut. Then the total length of the roots were measured. Table 7 shows the average of 6 seedlings of each lot.

TABLE 7

	Root Length (cm) 0 ppm	0.01 ppm	0.03 ppm
Condition A	30.8	37.4	36.6
Condition B	35.8	40.8	40.7

As Table 7 clearly shows, the addition of 5-ALA promoted the growth and rooting and thus good seedlings were grown.

EXAMPLE 6

A 5-ALA containing broth was prepared using a photosynthetic bacterium with the use of anaerobically treated swine feces as a medium in accordance with the method described in detail in JP-A-2-92293 (the term "JP-A" as used herein means an "unexamined published Japanese patent application"). This broth was centrifuged at 8,000 rpm for 30 minutes to give a supernatant. The obtained supernatant contained 720 ppm of 5-ALA. Then, the procedure of Example 4 was repeated, except that this broth was diluted to give a definite 5-ALA concentration and the culture was performed for 3 days. After 3 days, the root length was measured. Table 8 shows the average value per sheet (10 seeds).

TABLE 8

5-ALA conc. (ppm)	Average root length (cm) Sheet 1	Sheet 2	Sheet 3
0	1.0	1.2	1.8
0.0072	2.1	2.7	3.1
0.036	2.9	3.0	3.1
0.072	2.6	3.0	3.2
0.72	2.7	2.9	3.0

As Table 8 clearly shows, the effects exerted by using the above-mentioned unpurified broth produced by the microorganism were comparable to those achieved by using purified products.

EXAMPLE 7

The husks of rice seedlings (akinishiki, above-ground length: about 15 cm) grown in a seedling-raising box were removed and the seedlings were cut so as to give a root length of 1 cm. Then these seedlings were introduced into 100 ml Erlenmeyer flasks containing 100 ml portions of Kasuga's solution A [pH 5.1; refer to Jikken Nogei Kagaku, II, 3rd Ed., Asakura Shoten, p. 306] containing 5-ALA at various concentrations and fixed therein. The roots were shaded with an aluminum foil. After growth at 28° C. under 5,000 lux for 7 days, the length of the regenerated root (the longest one) was measured. Table 9 shows the results.

TABLE 9

5-ALA conc. (ppm)	Root length (cm)				
Lot No.	0	0.001	0.01	0.1	1
1	3.4	5.1	6.1	6.8	6.3
2	4.7	6.1	6.5	7.0	6.3
3	4.7	6.6	7.0	7.6	6.7
4	4.8	6.7	8.0	8.6	7.1

As Table 9 clearly shows, the addition of 5-ALA promoted the growth and the rooting and thus good seedlings were grown.

EXAMPLE 8

On Jun. 22, rice seedlings (akinishiki, above-ground length: about 12 cm) grown in a seedling-raising box were transplanted in a paddy field pot of 1/2000 a, prepared by a conventional method, at a ratio of 2 seedlings in 4 points per pot.

Immediately after the transplanting, 10 g, 30 g and 100 g per 10 a of 5-ALA was applied to the soil, while an untreated lot was also prepared as a control. Then the seedlings were managed under common conditions at a water depth of about 2 cm. On Jul. 10 (i.e., 18 days after the transplantation), the soil was washed away and the above-ground length and the total dry weight of each seedling were measured. Table 10 shows the results expressed as the average per pot.

TABLE 10

	Above-ground length (cm)	Dry weight (g)
Untreated	34.2 (100)	1.82 (100)
10 g/10 a	38.6 (113)	2.46 (135)
30 g/10 a	39.7 (116)	2.33 (128)
100 g/10 a	41.5 (121)	2.76 (152)

*: Figures given in parentheses are ratios with reference to the data of the untreated lot (%).

As Table 10 clearly shows, the treatment with 5-ALA promoted the growth. Further, the ratio of the weight gain exceeded that of the elongation in the above-ground length, which indicated that the treatment with 5-ALA did not cause spindly growth, which might result in lodging, but rather resulted in normal growth of the plants. Thus, it was found out that the invention agent contributed to the growth of good seedlings and was highly effective in practice.

EXAMPLE 9

On Jul. 17, rice seedlings (akinishiki, above-ground length: about 10 cm) grown in a seedling-raising box were transplanted in a paddy field pot of 1/2000 a, prepared by a conventional method, at a ratio of 2 seedlings in 4 points per pot.

Immediately after the transplanting, 4 ml portions of 5-ALA aqueous solutions of various concentrations, each containing the spreader neoesterin diluted to 2,000-fold (aqueous solution: spreader=2,000:1, hereinafter the same), were sprayed onto the pots (80 1/10 a). Then the seedlings were managed under common conditions at a water depth of about 2 cm. On Aug. 7 (i.e., 3 weeks after the transplantation), the soil was washed away and the above-ground length, the total dry weight and the number of tillers of each seedling were measured. Table 11 shows the results expressed as the average per pot.

TABLE 11

5-ALA conc.		Above-ground length (cm)	Dry weight (g)	No. of Tillers
Untreated	1	51.0	1.44	2.7
	2	47.4	1.53	3.0
	3	48.9	1.56	3.0
	4	49.9	1.58	3.0
10 ppm	1	47.6	1.65	3.0
	2	50.5	1.73	3.2
	3	49.9	2.19	3.4
30 ppm	1	48.8	2.14	3.2
	2	52.9	2.15	3.3
	3	50.9	2.16	3.4
	4	50.2	2.21	3.5
100 ppm	1	51.1	2.05	3.3
	2	52.1	2.15	3.3
	3	49.6	2.45	3.5
	4	49.7	2.46	3.5

As Table 11 clearly shows, the treatment with 5-ALA promoted the growth and increased the rooting ration. Further, the dry weight and tiller number were remarkably increased, while the above-ground length showed little elongation, which indicated that the seedlings were highly resistant against lodging and high yield could be expected.

EXAMPLE 10

On Jun. 22, the roots of rice seedlings (akinishiki, above-ground length: about 12 cm) grown in a seedling-raising box were soaked in 5-ALA aqueous solutions of various concentrations for 12 hours so as to allow the seedlings to absorb the solutions. On Jun. 23, these seedlings were transplanted into the same pots as those used in the above Example 8 in the same manner and then they were managed under common conditions at a water depth of about 2 cm till Jul. 10 (namely, for 17 days). On Jul. 10, the soil was washed away and the above-ground length and total dry weight of each seedling were measured. 2 pots were employed for each concentration and thus 16 seedlings were used. Table 12 shows the results expressed in average.

TABLE 12

5-ALA conc. (ppm)	Above-ground length (cm)	Total dry weight (g)
0	35.2	1.67
0.01	34.8	1.79
0.1	35.0	1.90
1	37.1	1.84
10	36.2	1.73

As Table 12 clearly shows, the treatment with 5-ALA promoted the growth and increased the rooting ratio. Further, the ratio of the weight gain exceeded that of the elongation in the above-ground length, which indicated that the treatment with 5-ALA promoted the normal growth of the plants without being accompanied by any spindly growth. Thus, it was found that the invention agent was highly effective in practice.

EXAMPLE 11

On Jun. 12, 10 radish seeds (comet, Sakata) were sowed in a 1/5000 a pot filled with field soil to which 10 kg/10 a, in terms of nitrogen, of a compound fertilizer (N:P:N=8:8:8 (wt %), the product of Nitto Hiryo Kagaku Kogyo K. K., Japan) had been applied as the basal dressing. Then, the seeds were cultured in a green-

house. On Jun. 26 (2 to 4 true leaf stage), the seedlings were thinned while leaving 4 seedlings of uniform size per pot. A spreader neoesterin was diluted 2,000-fold with 5-ALA solutions of various concentrations. Then the seedlings were subjected to foliage treatment with 2 ml per pot of the solutions thus obtained. The seedlings were managed under common conditions till Jul. 4 and then harvested. The harvested plants were washed with water and dried in a drier at 80° C. for 24 hours, followed by weighing each seedling. Table 13 shows the results expressed in the average weight per pot.

TABLE 13

5-ALA conc. (ppm)	Average dry weight (g/seedling)
0	0.97
1	1.04
3	1.17
10	1.17
30	1.36
100	1.34
300	1.26

As Table 13 clearly shows, the treatment with 5-ALA promoted the growth and increased the yield.

EXAMPLE 12

On Jun. 12, 10 corn seeds (honey bantam sweet corn, Sakata) were sowed in a 1/5000 a pot filled with field soil to which 10 kg/10 a, in terms of nitrogen, of a compound fertilizer had been applied as the base dressing. Then the seeds were cultured in a greenhouse. On Jun. 26 (3 to 4 leaf stage), the seedlings were thinned while leaving 7 seedlings of uniform size per pot. A spreader neoesterin was diluted 2,000-fold with 5-ALA solutions of various concentrations. Then the seedlings were subjected to foliage treatment with 2 ml per pot of the solutions thus obtained.

The seedlings were managed under common conditions. On Jul. 7, the above-ground parts were cut (5 to 6 leaf stage) and the above-ground length and the above-ground weight (wet weight) of each seedling were measured and the average values per pot were calculated. Table 14 shows the results.

TABLE 14

5-ALA conc.	Average above-ground weight		Average above-ground length	
(ppm)	(g/seedling)	(%)	(cm/seedling)	(%)
0	2.88	(100)	43.6	(100)
3	2.93	(102)	43.8	(100)
10	3.76	(131)	47.5	(109)
30	3.72	(129)	45.6	(105)
100	3.36	(117)	45.4	(104)
300	3.11	(108)	46.2	(106)

As Table 14 clearly shows, the treatment with 5-ALA promoted growth. Further, the above-ground weight gain exceeded that of the elongation in the above-ground length, which indicated that the treatment with 5-ALA promoted the normal growth of the plants without being accompanied by any spindly growth. Thus, it was found out that good seedlings highly resistant against lodging were obtained.

EXAMPLE 13

On Jul. 10, 6 soybeans (akishirome) were sowed in a 1/5000 a pot filled with field soil to which 10 kg/10 a, in terms of nitrogen, of a compound fertilizer had been applied as the basal dressing. Then, the beans were cultured in a greenhouse. On Jul. 24 (first compound leaf stage), the seedlings were thinned while leaving 3 seedlings of uniform size per pot. A spreader neoesterin was diluted 2,000-fold with 5-ALA solutions of various concentrations. Then the seedlings were subjected to foliage treatment by spraying 3 ml per pot of the solutions thus obtained thereon.

The seedlings were managed under common conditions. On Aug. 11, the soil was washed away with water and the seedlings were harvested. After measuring the above-ground length, each seedling was dried in a drier at 80° C. for 24 hours, followed by weighing. Table 15 shows the results expressed in the average data per pot.

TABLE 15

5-ALA conc. (ppm)	Average total weight (g/plant)	Average above-ground length (cm/plant)
0	1.68	37.7
10	1.99	41.4
30	2.13	42.1
100	1.79	40.6

As Table 15 clearly shows, the treatment with 5-ALA promoted the growth and thus good seedlings were effectively grown.

EXAMPLE 14

On Jun. 12, 8 kidney beans (Aron, Sakata) were sowed in a 1/5000 a pot filled with field soil to which 10 kg/10 a, in terms of nitrogen, of a compound fertilizer had been applied as the basal dressing. Then, the beans were cultured in a greenhouse. On Jul. 3 (first compound leaf stage), the seedlings were thinned while leaving 4 seedlings of uniform size per pot. A spreader neoesterin was diluted 2,000-fold with 5-ALA solutions of various concentrations. Then the seedlings were subjected to foliage treatment by spraying 2 ml per pot of the solutions thus obtained thereon.

The seedlings were managed under common conditions. On Jul. 17, the soil was washed away with water and the seedlings were harvested. Then, the above-ground fresh weight of each seedling was measured and the leaves were counted. Then the roots were separated from the above-ground part and dried in a drier at 80° C. for 24 hours, followed by determining the dry weight per pot. 3 pots were employed for each concentration. The above-ground weight and leaf number were expressed as an average per plant, while the dry root weight was expressed as an average value per pot. Table 16 shows the results.

TABLE 16

5-ALA conc. (ppm)	Average above-ground weight (g/plant)	Average number of leafs (No./plant)	Average dry root weight (g/pot)
0	5.6	7.3	3.3
1	6.3	7.5	3.7
3	6.7	7.4	3.5
10	6.7	8.4	5.0
30	6.9	8.3	6.5
100	6.8	8.3	5.7
300	6.2	7.8	4.8

As Table 16 clearly shows, the treatment with 5-ALA promoted growth. Further, the increase in the average leaf number indicated that the growth of the

plant was promoted, the time required for harvesting was shortened and the growth period was shortened.

Furthermore, the treatment with 5-ALA exerted a marked effect on the dry root weight. Thus, it was found that the invention agent was highly effective in promoting rooting, increasing the rooting ratio and in

EXAMPLE 15 and COMPARATIVE EXAMPLE 1

On Aug. 24, tips of sweet potato runners each having 5 leaves were cut. From those of uniform size, 2 leaves from the bottom were removed and the stems were soaked in 5-ALA aqueous solutions of various concentrations and in a Sun-catch TM (product of Mitsubishi Gas Chemical Co., Inc.) aqueous solution adjusted to such a concentration so as to contain 20 ppm of choline chloride for 24 hours. After 24 hours (Aug. 25), these stems were vertically transplanted in deep pots No. 8 (diameter: 24 cm) filled with field soil in such a manner that the remaining 3 leaves were located above ground. Then water was sufficiently given and the plants were grown in a greenhouse for 2 weeks. On Sep. 7, the soil was washed away with water and each root thus formed was cut with a scalpel. The obtained roots were dried in a drier at 50° C. for 48 hours. 4 pots were employed for each solution and the average dry root weight of 4 stems was determined. Table 17 shows the results.

TABLE 17

	5-ALA conc. (ppm)	Dry root weight (g/ plant)	Gain (%)
Ex. 15	0	0.42	100
	0.01	1.07	255
	0.1	0.79	188
	1	0.62	148
	10	0.51	121
C. Ex. 1	Sun-catch TM (20 ppm)	0.73	174

As Table 17 clearly shows, the treatment with 5-ALA promoted growth and rooting and increased the rooting ratio. When compared with Comparative Example 1, the invention agent was twice or more as effective as Sun-catch TM, Which is a plant growth promoter known to be effective in increasing the rooting ratio of potatoes, even at a concentration as low as 1/2,000.

EXAMPLE 16

On Sep. 1, 2 ridges 1 m in width were formed on a field to which 10 kg/10 a, in terms of nitrogen, of a compound fertilizer had been applied as a basal dressing. Then two varieties of radish seeds (miyashige-sobutori, tensei-aokubi), were sowed each in 2 lines and then managed under common conditions (thinning and top dressing). On Oct. 1 (after 1 month), radish seedlings of each variety were divided into 2 groups. Then a 5-ALA (100 ppm) aqueous solution containing a spreader neoesterin diluted 2,000-fold was sprayed onto the leaves of the seedlings of one group, while a solution prepared by adding neoesterin in the same amount as described above to water was sprayed onto the seedlings of the other group, each in a dose of 1 ml per plant.

Next, the plants were managed under common conditions. On Oct. 18, the diameter of the thickest portion of the above-ground part of each radish was measured with a slide caliper.

Table 18 shows the obtained data and average values.

TABLE 18

	Diameter (cm)		Diameter (cm)	
	Miyashige treated	Miyashige untreated	Tensei treated	Tensei untreated
Average	55.9	51.5	60.2	56.6
Standard deviation	5.4	5.9	7.5	9.0

As Table 18 clearly shows, the treatment with 5-ALA also promoted growth and increased yield in the field. Although differences in diameter were seemingly small, thickness is an important factor in the evaluation of a radish and the above differences in diameter corresponded to about 20% in radish weight. Thus, the effects achieved by the invention agent were highly useful.

EXAMPLE 17 and COMPARATIVE EXAMPLE 2

On Dec. 3, onion seedlings (SENSYUchukoudaka kitamanegi) were sealed in vinyl bags and allowed to stand in an incubator at 37° C. for 48 hours to thereby damage the seedlings. Next, the leaves were cut at 10 cm above the above-ground part. These seedlings were washed with water and the roots were soaked in 5-ALA aqueous solutions of various concentrations and in a Sun-catch TM aqueous solution adjusted so as to contain 20 ppm of choline chloride for 12 hours.

The onion seedlings thus treated were transplanted onto a ridge (width: 1 m) in a field, to which 10 kg/10 a, in terms of nitrogen, of a compound fertilizer had been applied as the basal dressing, at intervals of 25 cm in 3 lines of 15 cm in width. Then the seedlings were managed under common conditions. On Mar. 26, plants showing good growth were counted. Table 19 shows the number of planted seedlings, the number of rooting seedlings and their rooting ratios.

TABLE 19

	5-ALA conc. (ppm)	No. of planted seedling	No. of rooting seedling	Rooting ratio (%)
Ex. 17	0	38	5	13.2
	0.001	18	9	50.0
	0.01	18	11	61.1
	0.1	18	16	88.9
	1	18	17	94.4
	10	18	9	50.0
C. Ex. 2	Sun-catch TM (20 ppm)	17	10	58.8

As Table 19 clearly shows, the treatment with 5-ALA increased the rooting ratio. It was observed that seedlings which withered without rooting were damaged by cold weather. Thus, it was found that the treatment with the invention agent could improve cold resistance. It was further found that the invention agent achieved superior effects at a lower concentration, compared with the conventional product employed in Comparative Example 2.

EXAMPLE 18 and COMPARATIVE EXAMPLE 3

On Jul. 17, 10 radish seeds (comet, Sakata) were sowed in a 1/5000 a pot filled with field soil to which 10 kg/10 a, in terms of nitrogen, of a compound fertilizer had been applied as the basal dressing. Then the seeds were cultured in a greenhouse. On Jul. 28, the seedlings were thinned while leaving 6 seedlings of uniform size

per pot. On Aug. 2, 12 pots of uniform size were selected. Then the CO_2 absorption concentration of each pot was determined by using a photosynthetic activity determination device (product of Shimadzu Seisakusho) at 27° C., at a reference gas flow rate of 0.5 l/min, at a target gas flow rate of 0.5 l/min, at a fan rate of 8 l/min and under 70,000 lux. Simultaneously, the increase in CO_2 due to respiration was determined under shaded conditions. Next, a solution of a spreader neoesterin diluted 1,000-fold, solutions prepared by adding 30 ppm of 5-ALA, 100 ppm of 5-ALA and Sun-catch, Sun-catch being added in such an amount as to give 100 ppm of choline chloride, to the solution of the spreader were applied by spraying at an amount of 3 ml per pot (3 pots for each solution).

Then, the seedlings were managed under common conditions. 2 days (Aug. 4), 5 days (Aug. 7) and 9 days (Aug. 11) after the application, the CO_2 absorption concentration and the increase in CO_2 due to respiration were determined by the same method as the one performed on Aug. 2. 26 days after the application (Aug. 28), the plants were harvested, washed with water and dried in a drier at 80° C. for 24 hours. Then, the total dry weight of each plant was measured. The CO_2 concentration of each pot at each point was calculated by referring to the CO_2 concentration measured prior to the treatment on Aug. 2 as 100%, and the average of 3 pots for each condition was determined. The total dry weight was also measured in the same manner. Tables 20, 21 and 22 show the results.

TABLE 20

	Photosynthesis activity (CO_2 absorption %)			
	Before treatment	After 2 days	After 5 days	After 9 days
Ex. 18				
spreader alone	100	112	114	89.7
5-ALA (30 ppm)	100	126	115	98.0
5-ALA (100 ppm)	100	122	120	103
C. Ex. 3				
Sun-catch TM (100 ppm)	100	115	108	102

TABLE 21

	Respiration activity (CO_2 generation %)			
	Before treatment	After 2 days	After 5 days	After 9 days
Ex. 18				
spreader alone	100	128	200	123
5-ALA (30 ppm)	100	96.3	139	89.2
5-ALA (100 ppm)	100	114	153	96.5
C. Ex. 3				
Sun-catch TM (100 ppm)	100	131	184	106

TABLE 22

	Total dry weight (g/pot)
Ex. 18	
spreader alone	2.97
5-ALA (30 ppm)	3.83
5-ALA (100 ppm)	3.53
C. Ex. 3	
Sun catch TM (100 ppm)	3.20

As Table 20 clearly shows, the treatment with 5-ALA increased photosynthetic activity. When compared with Comparative Example 3, it was found that this effect of the invention agent was superior to that of Sun-catch TM. As Table 21 clearly shows, the treatment with 5-ALA lowered the respiration activity. When compared with Comparative Example 3, it was found that this effect of the invention agent was superior to that of Sun-catch TM Table 22 shows that the treatment With the invention agent was effective on the total dry plant weight after the treatment. Thus, it was found that the invention agent promoted growth and increased yield. When compared with Comparative Example 3, it was found that these effects of the invention agent were superior to those of Sun-catch TM.

The above Tables 20, 21 and 22 su99est, in total, that the treatment with the invention agent: (1) increased photosynthetic activity; (2) increased plant weight but suppressed the respiration per pot (namely, the effect per biomass exceeded the apparent effect given in Table 21); (3) promoted growth; and (4) elevated yield.

When compared with Comparative Example 3, all of the above-mentioned effects (1) to (4) were superior to those of the marketed plant growth promoter Sun-catch TM.

EXAMPLE 19

Shoot primordia derived from horse radish were aseptically planted into test tubes (40 mm in diameter, 150 mm in height) each containing 30 ml of LS (Linsmaier-Skoog) medium containing 2 ppm of NAA (1-naphthalene acetic acid), 0.02 ppm of BA (benzyladenine), 3% by weight of sucrose and 5-ALA at various concentrations. Then, the shoot primordia were cultured at 25° C. while cyclically irradiating at 6,000 lux for 16 hours and in the dark for 8 hours for 4 weeks. When observed with the naked eye, the plants of the 5-ALA addition groups showed an obvious dark green color, compared with those of the control group. In order to quantitatively analyze the difference in green color, about 4 g of these shoot primordia were ground together with beach sand in an agate mortar and chlorophyll was extracted with acetone/water (ratio by volume 80:15). Then the chlorophyll was redissolved in ethyl ether. After dehydrating, the absorbance was determined at 660 nm and 642.5 nm. Thus, the total chlorophyll content was calculated in accordance with the method described in Shokuhin Kogaku Jikkensho (Yokendo, 1970, p. 496).

$$\text{Total Chlorophyll Amount (mg/sample (g))} = \frac{Abs.\ (660\ nm) \times 7.12 + Abs.\ (642.5\ nm) \times 16.5}{\text{Sample Weight (g)}} \times \text{Dilution Ratio}$$

2 tubes were employed for each concentration and the average value was calculated. Table 23 shows the results.

TABLE 23

5-ALA conc. (ppm)	Chlorophyll content (mg/100 g)
0	23.5
0.01	24.7
0.03	25.3
0.1	35.5
1.0	34.0
3.0	35.5

TABLE 23-continued

5-ALA conc. (ppm)	Chlorophyll content (mg/100 g)
10.0	29.1

As Table 23 clearly shows, the treatment with 5-ALA increased the chlorophyll content. Thus, it was found that the invention agent contributed to promotion of growth, maintenance of freshness, improvement and maintenance in green color, improvement in photosynthetic activity and improvement in the capability to absorb CO_2.

EXAMPLE 20

On Dec. 18, 10 radish seeds (comet, Sakata) were sowed in a 1/5000 a pot filled with field soil to which 10 kg/10 a, in terms of nitrogen, of a compound fertilizer had been applied as the basal dressing. Then, the seeds were cultured in a greenhouse without heating and managed under common conditions. On Feb. 7 (2 to 4 true leaf stage), the seedlings were thinned while leaving 4 seedlings of uniform size per pot. Then, aqueous solutions containing 30 ppm of 5-ALA and 0.1% of various surfactants (for example, anionic surfactants (e.g., TU-21), cationic surfactants (e.g., EX-124, EX-94, EX-122), nonionic surfactants (e.g., Sorbon T-20, Sorbon T-80, TU-54, TU-59, TU-67, EX-118), amphoteric surfactants) were applied to the seedlings by spraying at a dose of 2 ml per pot. After managing in the unheated greenhouse under common conditions, the seedlings were harvested on Mar. 13. Then, the total weight, root part weight and the above-ground part weight of each plant were measured and the average data were calculated. Table 24 shows the results.

TABLE 24

No.	Weight (g)		
	Total	Root	Above-ground
1 untreated	7.8	4.4	3.4
2 5-ALA alone	9.5	5.4	4.1
3 + neoesterin	9.6	5.2	4.5
4 + TU-59	11.1	6.6	4.4
5 + TU-67	8.8	4.2	4.6
6 + TU-21	11.0	6.6	4.4
7 + EX-124	10.2	5.8	4.3
8 + EX-118	12.1	7.1	5.0
9 + EX-94	11.3	6.7	4.6
10 + EX-122	10.7	6.4	4.3
11 + EX-59	11.5	6.8	4.7
12 + sorbon T-20	12.1	7.2	4.9
13 + sorbon T-80	11.1	6.6	4.5

No. 3: a surfactant produced by Kumiai Chemical Industry Co., Ltd.
No. 4–No. 13: surfactants produced by Toho Chemical Industry Co., Ltd.

Thus, the treatment with 5-ALA clearly promoted growth and increased yield. These effects were exerted on both the above-ground and underground parts of the seedlings. It was further found that these effects were enhanced by adding surfactants and that various surfactants were usable for this purpose.

EXAMPLE 21

On Oct. 5, 5 wheat seeds (Norin No. 61) were sowed in a 1/5000 a pot filled with field soil to which 10 kg/10 a, in terms of nitrogen, of a compound fertilizer had been applied as the basal dressing. Then the seeds were cultured in a greenhouse under common conditions. On Nov. 8, the seedlings were thinned while leaving 4 seedlings of uniform size per pot. Then, these seedlings were cultured under 3,000 lux illumination with a fluorescent lamp from 15 to 22 o'clock. On Jan. 18, aqueous solutions containing 5-ALA at various concentrations and a spreader neoesterin diluted 2,000-fold were sprayed thereon at a dose of 4 ml per pot. After managing under common conditions, water was horizontally hosed upon the plants while were about 50 cm in height on Feb. 4 and thus all of the plants were lodged. Then, the plants were managed as such in a common manner and the recovery ratio was examined on Feb. 8.

4 pots (16 plants) were employed for each concentration. Table 25 shows the results.

TABLE 25

Conc. (ppm)	No. of recovering plants	Recovery ratio (%)
0	9	56
30	15	94
100	16	100

As Table 25 clearly shows, the treatment with 5-ALA contributed to the growth of good seedlings and thus lodging was reduced. Thus, it was found out that the invention agent was effective in increasing yield.

EXAMPLE 22

On Oct. 5, 5 wheat seeds (Norin No. 61) were sowed in a 1/5000 a pot filled with field soil to which 10 kg/10 a, in terms of nitrogen, of a compound fertilizer had been applied as the base dressing. Then, the seeds were cultured in a greenhouse under common conditions. On Nov. 8, the seedlings were thinned while leaving 4 seedlings of uniform size per pot. Then, these seedlings were cultured under 3,000 lux illumination with a fluorescent lamp from 15 to 22 o'clock. On Feb. 13 (heading/before blooming stage), aqueous solutions containing 5-ALA at various concentrations and a spreader neoesterin diluted 2,000-fold were sprayed thereon at a dose of 4 ml per pot. 10 pots were employed for each concentration. After managing under common conditions, the heads were harvested on Mar. 25 and threshed. Then, the grains were washed with water and less mature ones and impurities were removed. The grains were dried at 80° C. for 24 hours and the weight and grain number per pot were determined. Table 26 shows the results expressed in the average for each concentration.

TABLE 26

5-ALA conc. (ppm)	Weight (g/pot)	No. of Grains (No./pot)	Grain weight (mg/grain)
0	6.4 (100%)	166 (100%)	38.6 (100%)
30	6.7 (105%)	177 (107%)	37.9 (98%)
100	7.1 (111%)	180 (108%)	39.4 (102%)

As Table 26 clearly shows, the treatment with 5-ALA increased both the weight and grain number, suggesting that yield was thereby increased.

Since no significant difference was observed in grain weight, it was considered that the increase in the matured grains contributed to the increase in yield.

EXAMPLE 23

The procedure of Example 22 was repeated except that 500-fold aqueous solutions of a liquid fertilizer (Hyponex TM; N:P:K=5:10:5 (wt %), produced by Murakami Bussan K. K., Japan (Japanese licensee for Hyponex) containing 5-ALA at various concentrations

were applied to the foot of each seedling. Table 27 shows the results.

TABLE 27

5-ALA conc. (ppm)	Weight (g/pot)	No. of Grains (No./pot)	Grain weight (mg/grain)
0	7.6 (100%)	204 (100%)	37.3 (100%)
30	8.5 (112%)	213 (104%)	39.9 (107%)
100	8.2 (108%)	206 (101%)	39.8 (107%)

As Table 27 clearly shows, the treatment with 5-ALA increased both the weight and grain number, suggesting that the yield was thereby increased.

Since the weight per grain was also increased, it was considered that the treatment with the invention agent contributed to the production of wheat of excellent quality.

EXAMPLE 24

2.5 g portions, on a wet basis, of hairly roots of horse radish derived by a conventional method were planted in a plant jar fermenter (Bioreactor CTB-33, product of Tai-Tech, K. K.) and cultured at 25° C., at a ventilation rate of 0.5 l/min and at 250 rpm using Nitsch media containing various concentrations of 5-ALA. The media were replaced every 7 days. Table 28 shows the weight of hairly roots in the second, third and fourth weeks.

TABLE 28

5-ALA conc. (ppm)	Fibrous root weight (g)		
	2 week	3 week	4 week
0	32.2	35.2	39.6
0.01	34.2	39.4	44.6
0.1	32.6	38.0	43.0

As Table 28 clearly shows, the treatment with 5-ALA promoted the growth of hairly roots. Thus, it was found that the invention agent was effective in promoting growth and rooting and increasing yield.

EXAMPLE 25

Hairly roots of horse radish were cultured in the same manner as described in Example 24. After 4 weeks, the plants were harvested and the peroxidase (POD) activities thereof were determined. Table 29 shows the results expressed in the POD unit at each 5-ALA concentration.

TABLE 29

5-ALA conc. (ppm)	POD activity (U/reactor)
0	37,400
0.01	57,400
0.1	55,700
1	56,500

As Table 29 clearly shows, the treatment with 5-ALA increased the POD activity per reactor. Thus, it was found that the invention agent was also effective in increasing the yield of a secondary metabolite such as POD.

EXAMPLE 26

On Oct. 12, 15 barley seeds (kashimamugi) were sowed in a 1/2500 a pot filled with field soil to which 10 kg/10 a, in terms of nitrogen, of a compound fertilizer had been applied as the basal dressing. Then, the seeds were cultured as 5-stem training in a greenhouse under long-day illumination. Then, the plants were classified into 2 test lots one of which was treated twice on Dec. 5 (before the blooming stage) and on Dec. 7 (at the blooming stage) while the other one group was treated twice on Dec. 7 (at the blooming stage) and on Dec. 17 (after the blooming stage). Then, they were subjected to foliage treatment with 5-ALA preparations of various concentrations and preparations containing 5-ALA together with epibrassinolide (EBR), each containing a surfactant neoesterin diluted 2,000-fold, at a ratio of 200 l per 10 a.

On Feb. 19, the barley plants were harvested. After drying, the yield of each lot was measured. 18 pots were employed for the untreated lot while 6 pots were employed for each test lot. Tables 30 and 31 show the results expressed as average values.

TABLE 30

Before blooming stage/blooming stage treatment

	Conc. (ppm)		Yield/pot	Ratio to untreated lot
	5-ALA	EBR	(g)	(%)
Untreated	0	0	2.10	100
5-ALA	30	0	3.01	143
5-ALA	100	0	2.81	134
5-ALA + EBR	30	0.01	3.19	152
5-ALA + EBR	100	0.01	3.08	147
5-ALA + EBR	30	0.1	3.32	158
5-ALA + EBR	100	0.1	3.29	157
EBR	0	0.01	2.34	111
EBR	0	0.1	2.57	122

TABLE 31

Blooming stage/after blooming stage treatment

	Conc. (ppm)		Yield/pot	Ratio to untreated lot
	5-ALA	EBR	(g)	(%)
Untreated	0	0	2.10	100
5-ALA	30	0	2.50	119
5-ALA	100	0	2.31	110
5-ALA + EBR	30	0.01	2.60	124
5-ALA + EBR	100	0.01	2.50	119
5-ALA + EBR	30	0.1	2.71	129
5-ALA + EBR	100	0.1	2.90	138
EBR	0	0.01	2.11	100
EBR	0	0.1	2.20	105

As Tables 30 and 31 clearly show, treatment with 5-ALA increased the yield. It was further found that the treatment was effective when performed either before, during or after the blooming stage but that the treatment performed before or during the blooming stage was more effective.

It was furthermore found that the combined use of 5-ALA with epibrassinolide enhanced the effects, which indicates that synergistic effects were achieved.

EXAMPLE 27

On Oct. 12, 15 wheat seeds (Norin No. 61) were sowed in a 1/2500 a pot filled with field soil to which 10 kg/10 a, in terms of nitrogen, of a compound fertilizer had been applied as the basal dressing. The seeds were then cultured as 5-stem training in a greenhouse under long-day illumination. Then, the plants were classified into 2 test lots one of which was treated twice on Nov. 29 (before the blooming stage) and on Dec. 5 (at the blooming stage) while the other group was treated twice on Dec. 5 (at the blooming stage) and on Dec. 15 (after the blooming stage). Then, they were subjected to foliage treatment with 5-ALA preparations of various

concentrations and preparations containing 5-ALA together with epibrassinolide (EBR), each containing a surfactant neoesterin diluted 2,000-fold, at a ratio of 200 l per 10 a.

On Feb. 28, the wheat plants were harvested. After drying, the yield of each lot was measured. 18 pots were employed for the untreated lot while 6 pots were employed for each test lot. Tables 32 and 33 show the results expressed as average values.

TABLE 32

Before blooming stage/blooming stage treatment				
	Conc. (ppm)		Yield/pot	Ratio to untreated lot
	5-ALA	EBR	(g)	(%)
Untreated	0	0	5.60	100
5-ALA	30	0	6.60	118
5-ALA	100	0	6.31	113
5-ALA + EBR	30	0.01	6.63	118
5-ALA + EBR	100	0.01	4.40	114
5-ALA + EBR	30	0.1	6.68	119
5-ALA + EBR	100	0.1	6.55	117
EBR	0	0.01	6.11	109
EBR	0	0.1	6.34	113

TABLE 33

Blooming stage/after blooming stage treatment				
	Conc. (ppm)		Yield/pot	Ratio to untreated lot
	5-ALA	EBR	(g)	(%)
Untreated	0	0	5.60	100
5-ALA	30	0	6.45	115
5-ALA	100	0	6.27	112
5 ALA + EBR	30	0.01	6.43	115
5-ALA + EBR	100	0.01	6.29	112
5-ALA + EBR	30	0.1	6.49	116
5-ALA + EBR	100	0.1	6.31	113
EBR	0	0.01	6.14	110
EBR	0	0.1	6.21	111

As Tables 32 and 33 clearly show, the treatment with 5-ALA increased the yield. It was further found that the treatment was effective when performed either before, during or after the blooming stage.

It was furthermore found that the combined use of 5-ALA with epibrassinolide enhanced the effects, which indicates that synergistic effects were achieved.

EXAMPLE 28

Rice seeds (hoshi-no-hikari) were pasteurized with Benlate T (Active ingredient is benomyl by Du Pon't) (diluted 200-fold) over day and night and then incubated in the dark at 30° C., thus hastening germination. After 2 days, 7,000 seeds were sowed in seedling-raising boxes (60 x 30 cm) filled with synthetic cultivation soil. A surfactant (neoesterin) was diluted 2,000-fold with 5-ALA solutions of various concentrations. Then the obtained solutions were sprayed at a ratio of 500 ml per box and then the seeds were covered with soil. After having allowed to stand in the seedling-raising boxes for 2 days, the seedling were grown in a greenhouse.

After 37 days, 50 plants at each concentration were selected at random. The above-ground length and leaf age of each plant were determined. Then the dry above-ground weight of each of 5 plants was measured and the average was calculated. Table 34 shows the results.

TABLE 34

5-ALA conc. (ppm)	Above-ground length (cm) (%)	Leaf age	Dry above-ground weight (g/5 plants) (%)
Untreated	14.9 (100)	3.28	0.115 (100)
0.3	15.0 (101)	3.18	0.118 (103)
1	15.2 (102)	3.07	0.119 (103)
3	14.7 (99)	3.05	0.124 (108)
10	15.2 (102)	3.13	0.129 (112)
30	15.7 (105)	3.15	0.145 (126)
100	15.8 (105)	3.20	0.141 (123)

As Table 34 clearly shows, the treatment with 5-ALA increased the above-ground weight, while scarcely changing the above-ground leaf age. Thus, it was found that the treatment with the invention agent contributed to the growth of desirable seedlings.

EXAMPLE 29

On Jul. 28, 5 soybean seeds (akishirome) were sowed in a 1/5000 a pot filled with field soil. The seedlings were grown as 4-stem training in a greenhouse. On Aug. 18 (the first compound leaf stage), the seedlings were subjected to foliage treatment with a surfactant (neoesterin) diluted 2,000-fold with 5-ALA solutions of various concentrations at a ratio of 100 l per 10 a. Similarly, soil treatment was performed with the use of the same preparations at a ratio of 100 l per 10 a. On Aug. 30, the growth of the soybean plants was examined and the above-ground weight was measured. Then, the average weight per plant was calculated. Tables 35 and 36 show the results. The fresh weight is the weight immediately after picking and the dry weight is the weight after treating at 80° C. for 24 hours in a drying apparatus.

TABLE 35

	Foliage treatment	
5-ALA conc.	Fresh weight (g;%)	Dry weight (g;%)
Untreated	14.8 (100)	3.07 (100)
30 ppm	16.8 (114)	3.50 (114)
100 ppm	17.5 (118)	3.71 (121)

TABLE 36

	Soil treatment	
5-ALA conc.	Fresh weight (g;%)	Dry weight (g;%)
Untreated	14.8 (100)	3.07 (100)
30 g/10 a	16.5 (111)	3.48 (113)
100 g/10 a	17.1 (116)	3.52 (115)

As Tables 35 and 36 clearly show, the treatment with 5-ALA promoted growth in each case.

EXAMPLE 30

On Oct. 27, 10 soybean seeds (akishirome) were sowed in a 1/5000 a pot filled with field soil. The seedlings were grown as 3-stem training in a greenhouse. On Dec. 21 and 28 (in the early stage of the pod appearing stage following blooming), the plants were subjected to foliage treatment with 200 per 10 a of solutions of 5-ALA at various concentrations each containing a surfactant (neoesterin) diluted 2,000-fold. On Jan. 13, the growth of the soybean plants was examined and pods were weighed. Table 37 shows the results.

TABLE 37

5-ALA conc. (ppm)	Total pod weight (g/pot)	Ratio to untreated lot (%)
Untreated	14.1	100
10	15.4	109
30	16.8	119
100	15.5	110
300	18.5	131

As Table 37 clearly shows, the treatment with 5-ALA promoted growth and increased yield.

EXAMPLE 31

On Aug. 27, 7 adzuki bean seeds (tamba-dainagon) were sowed in a 1/5000 a pot filled with field soil to which 10 kg/10 a, in terms of nitrogen, of a compound fertilizer had been applied as the basal dressing. The seedlings were grown as 3-stem training in a greenhouse. On Sep. 10 (the first compound leaf stage) and on Sep. 17 (the second compound leaf stage), the plants were subjected to foliage treatment with 100 l per 10 a of solutions of 5-ALA at various concentrations each containing a surfactant (neoesterin) diluted 2,000-fold. On Oct. 1 and on Oct. 11, respectively, the growth of the adzuki bean plants was examined and the above-ground part was weighed. Then the average weight per plant was calculated. Tables 38 and 39 show the results.

TABLE 38

	Treatment in 1st compound leaf stage	
5-ALA conc. (ppm)	Fresh weight (g) (%)	Dry weight (g) (%)
Untreated	4.55 (100)	1.01 (100)
30	4.99 (110)	1.04 (103)
100	5.76 (127)	1.23 (122)
300	4.98 (109)	1.11 (110)

TABLE 39

	Treatment in 2nd compound leaf stage	
5-ALA conc. (ppm)	Fresh weight (g) (%)	Dry weight (g) (%)
Untreated	4.41 (100)	1.13 (100)
30	4.71 (107)	1.19 (105)
100	4.90 (111)	1.21 (107)
300	4.71 (107)	1.18 (104)

As Tables 38 and 39 clearly show, the treatment with 5-ALA promoted growth. The treatment was effective when performed either in the first compound leaf stage or in the second compound leaf stage, though the former was more effective. The treatment affected the dry weight as well as the fresh weight, which indicates that the invention agent not only increased the moisture content but also promoted the growth of the plants per se.

EXAMPLE 32

On Sep. 10, adzuki bean seeds (tamba-dainagon) were sowed in a 1/5000 a pot filled with field soil to which 10 kg/10 a, in terms of nitrogen, of a compound fertilizer had been applied as the basal dressing. The seedlings were grown as 3-stem training in a greenhouse. On Nov. 22 (in the early part of the pod appearing stage), the plants were subjected to foliage treatment with 500 l per 10 a of solutions of 5-ALA at various concentrations each containing a surfactant (neoesterin) diluted 2,000-fold. On Jan. 18, the growth of the adzuki bean plants was examined and the fresh beans were weighed. Table 40 shows the results.

TABLE 40

5-ALA conc. (ppm)	Total bean weight (g/pot)	Ratio to untreated lot (%)
Untreated	11.2	100
10	11.5	103
30	12.2	109
100	12.9	115
300	17.4	155

As Table 40 clearly shows, the treatment with 5-ALA promoted growth and increased yield.

EXAMPLE 33

On Dec. 1, corn seeds (pioneer) were sowed on river sand which had been well washed with water. Then they were grown in a greenhouse till the 2.5 leaf stage. On Dec. 14, seedlings of uniform size were selected and the foliage part of each young seedling thus selected was soaked in solutions of 5-ALA at various concentrations each containing a surfactant (neoesterin) diluted 2,000-fold for 5 minutes. When the surface of leaves was dried, the seedlings were transplanted into a 1/5000 a pot filled with field soil to which 10 kg/10 a of a compound fertilizer had been applied as the basal dressing. Then, the seedlings were grown in a greenhouse. On Jan. 12, the growth of the corn plants was examined and the fresh weight was measured. The average per plant was then calculated. Table 41 shows the results.

TABLE 41

5-ALA conc. (ppm)	Total weight (g/pot)	Ratio to untreated lot (%)
Untreated	7.97	100
3	8.51	107
10	8.65	109
30	9.29	117
100	9.38	118
300	9.30	117

As Table 41 clearly shows, the treatment with 5-ALA promoted growth.

In the treatment of this Example, the chemical was never absorbed from roots, different from conventional foliage treatment. Thus, it was found that the invention agent absorbed through leaves exerted the desired effects.

EXAMPLE 34

On Jul. 28, 10 corn seeds (pioneer) were sowed in a 1/2500 a pot filled with field soil to which 10 kg/10 a of a compound fertilizer had been applied as the basal dressing. Then, the seedlings were grown as 4-stem training in a greenhouse. On Aug. 18 (2.5 leaf stage), the plants were subjected to foliage treatment with 100 l per 10 a of solutions of 5-ALA at various concentrations each containing a surfactant (neoesterin) diluted 2,000-fold or to soil treatment therewith similarly at an amount of 100 l per 10 a. On Sep. 3, the growth of the corn plants was examined and the dry above-ground weight was measured. Then the average growth per plant was calculated. Tables 42 and 43 show the results.

TABLE 42

5-ALA conc. (ppm)	Foliage treatment Dry weight (g)	Ratio to untreated lot (%)
Untreated	6.84	100
30	8.74	127
100	8.08	118
300	7.86	115

TABLE 43

5-ALA conc. (g/10 a)	Soil treatment Dry weight (g)	Ratio to untreated lot (%)
Untreated	6.86	100
30	8.50	124
100	8.28	121
300	8.40	122

As Tables 42 and 43 clearly show, the treatment with 5-ALA promoted growth, either in the foliage treatment or in the soil treatment.

EXAMPLE 35

On Nov. 15, radish seeds (comet, Sakata) were sowed in a 1/5000 a pot filled with field soil to which 10 kg/10 a, in terms of nitrogen, of a compound fertilizer had been applied as the basal dressing. Then, the seedlings were grown as 3-stem training in a greenhouse. On Dec. 8 (2 leaf stage), 15, 21 and 28, the seedlings were subjected to foliage treatment each with a solution of 100 ppm of 5-ALA containing a surfactant (neoesterin) diluted 2,000-fold at a ratio of 200 l/10 a. On Jan. 12, the growth of the radish plants was examined and the fresh weight was measured. The average growth per plant was calculated. Table 44 shows the results.

TABLE 44

Date	Fresh weight (g)	Ratio to untreated lot (%)
Untreated	18.0	100
12/8	20.5	114
12/15	21.8	121
12/21	22.2	123
12/28	21.4	119

As Table 44 clearly shows, the treatment with 5-ALA promoted growth and increased yield. The invention agent exerted its effects when applied in any stage, which suggested that it was applicable over a wide range of period.

EXAMPLE 36

10 kg/10 a, in terms of nitrogen, of a compound fertilizer was applied to a field as the basal dressing and 2 ridges (80 cm in width, 5 m in length) were formed. On Sep. 12, 10 l/10 a of radish seeds (comet) were sowed therein and grown under common conditions. A surfactant (neoesterin) was diluted 2,000-fold with 5-ALA solutions of various concentrations. Then, the seedlings were subjected to foliage treatment with 200 per 10 a of the solutions on Sep. 26 (2.5 leaf stage) in the case of the 1-treatment lot and on Sep. 26 and on Oct. 16 in the case of the 2-treatment lot. On Oct. 29, the radishes were harvested and their fresh weight was measured. The average weight per plant was calculated. Tables 45 and 46 show the results.

TABLE 45

5-ALA conc. (ppm)	1-Treatment lot Fresh weight (g)	Ratio to untreated lot (%)
Untreated	30.5	100
30	36.7	120
100	44.3	145
300	40.2	132

TABLE 46

5-ALA conc. (ppm)	2-Treatment lot Fresh weight (g)	Ratio to untreated lot (%)
Untreated	30.5	100
30	40.2	132
100	44.6	147
300	48.4	159

As Tables 45 and 46 clearly show, the treatment with 5-ALA promoted growth and increased yield in field cultivation.

It was further found that the effects were enhanced by performing the treatment twice, which suggested that repeated treatment was effective.

EXAMPLE 37

10 kg/10 a, in terms of nitrogen, of a compound fertilizer was applied as the basal dressing to a field the pH of which had been adjusted to 6.8 with slaked lime. Then two ridges (110 cm in width, 5 m in length) were formed. On Nov. 6, 15 l/10 a of spinach seeds (Autumn horenso) were sowed in each ridge in 3 lines. On Nov. 15, the ridges were coated with a vinyl sheet and then plastic greenhouse (tunnel) cultivation was performed in a conventional manner. On Dec. 12, the plants were subjected to foliage treatment with 200 l per 10 a of 5-ALA solutions of various concentrations each containing a surfactant (neoesterin) diluted 2,000-fold. At the application, the spinach seedlings were in the 3 to 5 true leaf stage. On Jan. 17, the plants were harvested and their fresh weight was determined. Table 47 shows the results expressed as the average fresh weight per plant.

TABLE 47

5-ALA conc. (ppm)	Fresh weight (g)	Ratio to untreated lot (%)
Untreated	9.77	100
10	12.1	124
30	11.7	120
100	12.3	126
300	10.9	112

As Tables 47 clearly shows, the treatment with 5-ALA also promoted growth and increased yield in field cultivation.

EXAMPLE 38

Pollens of tea plant flowers were inoculated into agar media (agar 1%) containing 10% sucrose and 5-ALA at various concentrations and incubated therein at 28° C. in the dark. After 24 hours, the elongation of the pollen tubes was measured. Table 48 shows the results.

TABLE 48

5-ALA conc. (ppm)	Average elongation (mm)	Ratio to untreated lot (%)
Untreated	3.0	100

TABLE 48-continued

5-ALA conc. (ppm)	Average elongation (mm)	Ratio to untreated lot (%)
0.001	3.6	120
0.01	4.1	137

As Table 48 clearly shows, 5-ALA promoted growth of the organ.

EXAMPLE 39

Korean lawn grass planted 10 years ago was divided into sections (50 cm×50 cm) and runners located boundary lines were cut with a cutter. Then, the grass was subjected to foliage treatment with 200 l per 10 a of 5-ALA solutions of various concentrations each containing a surfactant (neoesterin) diluted 2,000-fold. 1-Treatment lots were treated on Oct. 4, while 2-treatment lots were treated on Oct. 4 and 27. On Dec. 7, 17 and 25 and on Jan. 9, the green color of the grass was evaluated. Table 49 shows the results.

TABLE 49

Date	1-Treatment lot				2-Treatment lot			
5-ALA conc.	12/7	12/17	12/25	1/9	12/7	12/17	12/25	1/9
Untreated	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
10 ppm	3.5	4.0	3.0	3.0	3.5	2.0	3.0	3.0
30 ppm	3.5	3.5	3.0	3.0	4.0	4.0	3.0	3.0
100 ppm	4.0	4.0	3.5	3.0	4.0	5.0	4.0	3.0
300 ppm	3.0	3.5	3.5	3.0	3.0	4.0	3.0	3.0
1000 ppm	2.5	2.5	2.5	3.0	2.0	2.5	2.5	3.0

The evaluation data were expressed in relative values of from 1.0 to 5.0, where the value of the untreated lot was 3.0. A higher value means a deeper green color. As Table 49 clearly shows, the treatment with the invention agent contributed to the maintenance of green color for a prolonged period of time.

EXAMPLE 40

Korean lawn grass planted 10 years ago was divided into sections (50 cm×50 cm) and runners located boundary lines were cut with a cutter. Then, the grass was subjected to foliage treatment with 200 l per 10 a of 5-ALA solutions of various concentrations each containing a surfactant (neoesterin) diluted 2,000-fold. 1-Treatment lots were treated on Oct. 4, while 2-treatment lots were treated on Oct. 4 and 27. On Jan. 23, the growth of the Korean lawn grass was examined. 4 samples (10.4 cm in diameter, 10 cm in depth) were collected from each section. After washing with water and drying, the dry weight was measured. Table 50 shows the results.

TABLE 50

5-ALA conc. (ppm)	1-Treatment		2-Treatment	
	Dry weight (g)	Ratio to untreated lot (%)	Dry weight (g)	Ratio to untreated lot (%)
0	22.3	100	24.7	100
10	26.0	117	27.3	111
30	25.3	113	25.7	104
100	24.1	108	25.7	104
300	23.6	106	25.7	104

As Table 50 clearly shows, the treatment with 5-ALA promoted the growth of the lawn grass.

EXAMPLE 41

2 ridges (2 m in width, 8 m in length), to which 10 kg/10 a, in terms of nitrogen, of a compound fertilizer had been applied as the basal dressing, were formed and 5 kg per 10 a of wheat seeds (norin No. 50) were sowed on Oct. 24. After growing under common conditions, the plants were subjected to foliage treatment with 200 l per 10 a of 5-ALA solutions of various concentrations or 5-ALA and epibrassinolide mixtures, each containing a surfactant (neoesterin) diluted 2,000-fold, twice on May 10 (before blooming stage) and on May 17 (blooming stage). 3 treated lots were employed. On Jul. 19, the harvested wheat was weighed. Table 51 shows the results.

TABLE 51

	Conc. (ppm)		Yield	Ratio to untreated lot
	5-ALA	EBR	(kg/10 a)	(%)
Untreated	0	0	48.3	100
5-ALA	30	0	52.1	108
5-ALA	100	0	52.5	109
5-ALA + EBR	30	0.1	52.9	110
5-ALA + EBR	100	0.1	52.6	109

As Table 51 clearly shows, the treatment with 5-ALA increased yield. The combined use of 5-ALA with EBR further showed synergistic effects.

EXAMPLE 42

2 ridges (2 m in width, 8 m in length), to which 10 kg/10 a, in terms of nitrogen, of a compound fertilizer had been applied as the basal dressing, were formed and 5 kg per 10 a of barley seeds (haruna nijo) were sowed on Oct. 20. After growing under common conditions, the plants were subjected to foliage treatment with 200 per 10 a of 5-ALA solutions of various concentrations or 5-ALA and epibrassinolide mixtures, each containing a surfactant (neoesterin) diluted 2,000-fold, twice on May 7 (before blooming stage) and on May 14 (blooming stage). 3 treated lots were employed. On Jul. 23, the harvested barley was weighed. Table 52 shows the results.

TABLE 52

	Conc. (ppm)		Yield	Ratio to untreated lot
	5-ALA	EBR	(kg/10 a)	(%)
Untreated	0	0	45.1	100
5-ALA	30	0	57.7	128
5-ALA	100	0	52.8	117
5-ALA + EBR	30	0.1	57.9	128
5-ALA + EBR	100	0.1	57.5	127

As Table 52 clearly shows, the treatment with 5-ALA increased yield. The combined use of 5-ALA with EBR further showed synergistic effects.

EXAMPLE 43

On Oct. 12, 15 wheat seeds (norin No. 61) were sowed in a 1/2500 a pot filled with field soil, to which 10 kg/10 a, in terms of nitrogen, of a compound fertilizer had been applied as the base dressing, and grown as 5-stem training in a greenhouse under long-day illumination. On Nov. 2 (before the blooming stage) and on Dec. 5 (blooming stage), the plants were subjected to foliage treatment with 8 ml per pot (200 l/10 a) of 5-ALA solutions of various concentrations each containing a spreader (neoesterin) diluted 2,000-fold using a sprayer. 6 pots were employed for each treatment. Following Feb. 12, one pot was harvested every other day and the ratio of matured grains was examined. Table 53 shows the results.

TABLE 53

5-ALA conc.	Matured grains (%)					
(ppm)	2/12	2/14	2/16	2/18	2/20	2/22
0	6	11	43	70	92	98
30	8	15	52	88	96	100
100	7	18	61	85	98	100

As Table 53 clearly shows, the treatment with 5-ALA shortened the time required for maturing.

EXAMPLE 44

Korean lawn grass planted 10 years ago was transplanted into a 1/2500 a pot filled with field soil, to which 10 kg/10 a, in terms of nitrogen, of a compound fertilizer had been applied as the basal dressing. After managing under common conditions, 6 pots showing uniform growth were selected on Jul. 31. Then, the carbon dioxide gas absorption and respiration were determined by the same method as employed in Example 18 except that illumination was performed at 80,000 lux. Then, a 1,000-fold dilution of neoesterin and the same solution containing 100 ppm of 5-ALA were sprayed respectively onto 3 pots at a ratio of 300 l per 10 a.

The plants were then managed under common conditions. On Aug. 1 (the next day after the application), 3 (3 days thereafter), 7 (7 days thereafter) and 14 (14 days thereafter), the CO_2 absorption concentration and the increase in CO_2 due to respiration were determined by the same method as performed on Jul. 31. The increase in CO_2 at each point for each pot was calculated with the data on Jul. 31 being taken as 100%. Then, the average of the data of 3 pots for each condition was determined. Tables 54 and 55 show the results.

TABLE 54

	Photosynthetic activity (CO_2 absorption %)				
	Before treatment	After 1 day	After 3 days	After 7 days	After 14 days
Spreader alone	100	101	111	123	127
5-ALA 100 ppm	100	117	146	149	146

TABLE 55

	Respiration activity (CO_2 generation %)				
	Before treatment	After 1 day	After 3 days	After 7 days	After 14 days
Spreader alone	100	114	140	143	155
5-ALA 100 ppm	100	101	113	111	128

As Tables 54 and 55 clearly show, the treatment with 5-ALA enhanced photosynthetic activity and simultaneously suppressed respiration activity.

EXAMPLE 45

To lawn grass pots, which were prepared and treated in the same manner as described in Example 44, 200 g per 10 a of Shimazine TM (a triazine-series herbicide; AI is CAT by Ciba-Geigy AG.) was applied. Next, a 1,000-fold dilution of neoesterin and the same solution containing 100 ppm of 5-ALA were sprayed respectively onto 3 pots at a ratio of 300 l per 10 a.

The plants were then managed under common conditions. On Aug. 1 (the next day after the application), 3 (3 days thereafter), 7 (7 days thereafter) and 14 (14 days thereafter), the CO_2 absorption concentration was determined by the same method as performed on Jul. 31. The CO_2 concentration at each point for each pot was calculated with the data on Jul. 31 being taken as 100%. Then, the average of the data of 3 pots for each condition was determined. Table 56 shows the results.

TABLE 56

	Photosynthesis activity (CO_2 absorption %)				
	Before treatment	After 1 day	After 3 days	After 7 days	After 14 days
Spreader alone	100	101	79	79	106
5-ALA 100 ppm	100	114	91	102	137

When the data given in the above Table 56 were compared with those of Table 54 in Example 44, it was found that the photosynthetic activity was lowered by the chemical damage due to the herbicide Shimazine.

As Table 56 clearly shows, the chemical damage due to Shimazine on photosynthetic activity was significantly relieved by the addition of 5-ALA and plant recovery was thereby promoted.

EXAMPLE 46

10 kg/10 a, in terms of nitrogen, of a compound fertilizer was applied to a field as the basal dressing and a ridge 1 m in width was formed. On Apr. 12, 10 l per 10 a of komatsuna seeds (maruba komatsuna, Nohara Shubyo K. K.) were sowed and then managed under common conditions. On Apr. 25, the seedlings were thinned. Thus, 9 test sections (1 m × 1 m) were prepared at intervals of 50 cm.

On May 13, the seedlings were subjected to foliage treatment with 5-ALA aqueous solutions of 0, 30 and 100 ppm each containing a surfactant (neoesterin) diluted 1,000-fold. 100 ml portions of the solution of each concentration was applied to 3 sections.

On May 23, the above-ground parts of the plants were harvested and the fresh weight was determined. The average weight per plant was then calculated. Table 57 shows the results.

TABLE 57

5-ALA conc. (ppm)	Fresh weight (g/plant)	Ratio to untreated lot (%)
0	11.6	100
30	13.2	114
100	12.8	110

As Table 57 clearly shows, treatment with 5-ALA increased yield.

EXAMPLE 47

The procedure of Example 46 was repeated except that the komatsuna seeds were replaced by rape seeds (norin No. 20, Nohara Shubyo K. K.). Table 58 shows the results.

TABLE 58

5-ALA conc. (ppm)	Fresh weight (g/plant)	Ratio to untreated lot (%)
0	10.2	100
30	11.2	110
100	14.3	140

As Table 58 clearly shows, treatment with 5-ALA increased yield.

EXAMPLE 48

10 kg/10 a, in terms of nitrogen, of a compound fertilizer was applied to a field as the basal dressing and a ridge 1 m in width and 10 m in length was formed. On Mar. 26, potato seed tubers (danshaku, Nohara Shubyo) were planted in 2 lines at intervals of about 50 cm. Then, the plants were managed under common conditions and buds were picked in such a manner as to leave 2 buds per plant. On Jul. 2, the seedlings were subjected to foliage treatment with 200 l/10 a of 5-ALA aqueous solutions of 0 and 100 ppm each containing a surfactant (neoesterin) diluted 1,000-fold. On Jul. 23, the potatoes were harvested and the number and weight were determined. Table 59 shows the results.

TABLE 59

5-ALA conc. (ppm)	0	100
No. of plants	44	40
Yield (g/plant)	344	560
Ratio to untreated lot (%)	100	163
No. of potatoes	4.8	6.9
Ratio to untreated lot (%)	100	144
Average weight (g/potato)	71.1	81.1
Ratio to untreated lot (%)	100	114

As Table 59 clearly shows, treatment with 5-ALA greatly increased yield. In particular, the yield per plant was increased by 63% and the weight per potato was also greatly increased, suggesting marked effects.

EXAMPLE 49

10 kg/10 a, in terms of nitrogen, of a compound fertilizer was applied to a field as the basal dressing and 3 ridges 1 m in width and 4 m in length were formed. On Oct. 5, garlic bulbs (Fukuchi White) were planted and managed under common conditions. On May 13, the plants were subjected to foliage treatment with 200 l/10 a of 5-ALA aqueous solutions of 0, 30 and 100 ppm each containing a surfactant (neoesterin) diluted 1,000-fold. On Jun. 5, the plants were harvested and the edible parts weighed. Table 60 shows the results.

TABLE 60

5-ALA conc. (ppm)	Yield (g/plant)	Ratio to untreated lot (%)
0	29.4	100
30	41.3	140
100	41.4	141

As Table 60 clearly shows, treatment with 5-ALA increased yield.

EXAMPLE 50

On May 15, soybean seeds (gokuwaseshiroge grand prix; Takayama Shubyo K. K.) were sowed in a 1/2500 a pot filled with field soil to which 15 kg/10 a, in terms of nitrogen, of a compound fertilizer had been applied as the basal dressing. The seedlings were grown as 3-stem training per pot and managed under common conditions.

Then, the plants were subjected to foliage treatment with 5-ALA solutions of 30 and 100 ppm, each containing a surfactant (neoesterin) diluted 2,000-fold. The time and dose of the treatment were as listed in Tables 61 and 62. 3 treated lots and 6 untreated lots were prepared.

On Jul. 28, the plants were harvested and the yield was examined. Tables 61 and 62 show the results.

TABLE 61

Treatment with 30 ppm of 5-ALA
Data given in parentheses are based on the untreated lot (%).

Date	Stage	Dose (l/10 a)	Pod weight (g/pod)	Bean weight (g/bean)	Yield (g/plant)
Untreated	—	—	1.76 (100)	0.52 (100)	15.9 (100)
5/15	True leaf 1	200	2.04 (116)	0.60 (116)	16.7 (105)
5/31	Compound leaf 1	200	1.99 (113)	0.55 (105)	16.1 (102)
6/5	Compound leaf 2	200	1.87 (106)	0.54 (105)	17.6 (111)
6/14	Compound leaf 3	200	1.93 (110)	0.58 (111)	16.0 (101)
6/26	Compound leaf 5 (blooming)	200	1.79 (102)	0.57 (111)	15.1 (95)
7/3	Early pod appearing	300	2.00 (114)	0.62 (119)	17.5 (110)
7/11	Medium pod appearing	300	1.76 (100)	0.55 (105)	15.9 (100)

TABLE 62

Treatment with 100 ppm of 5-ALA
Data given in parentheses are based on the untreated lot (%).

Date	Stage	Dose (l/10 a)	Pod weight (g/pod)	Bean weight (g/bean)	Yield (g/plant)
Untreated	—	—	1.76 (100)	0.52 (100)	15.9 (100)
5/15	True leaf 1	200	2.08 (118)	0.61 (117)	16.8 (106)
5/31	Compound leaf 1	200	2.17 (124)	0.62 (120)	18.9 (119)
6/5	Compound leaf 2	200	2.08 (118)	0.57 (110)	17.1 (108)
6/14	Compound leaf 3	200	1.89 (107)	0.59 (114)	17.9 (113)
6/26	Compound leaf 5 (blooming)	200	2.01 (114)	0.64 (123)	15.5 (98)
7/3	Early pod appearing	300	1.95 (111)	0.61 (118)	16.2 (102)

TABLE 62-continued

Date	Stage	Treatment with 100 ppm of 5-ALA. Data given in parentheses are based on the untreated lot (%). Dose (l/10 a)	Pod weight (g/pod)	Bean weight (g/bean)	Yield (g/plant)
7/11	Medium pod appearing	300	2.07 (118)	0.61 (118)	16.4 (104)

As Tables 61 and 62 show, treatment with 5-ALA increased yield. In particular, the treatment was effective when performed in the seedling stage (true leaf stage 1 to compound leaf stage 2) and the bean maturing stage (pod appearing stage). In the blooming stage, both the pod weight and bean weight were increased, though the yield was rather decreased. The bean weight, which most largely affected quality, reached a maximum level in this stage. These facts indicated that treatment with 5-ALA suppressed seed setting and thus beans of high quality were obtained. Thus, it was found that the treatment with the invention agent contributed not only to an increase in yield but also to an adjustment of seed setting and to an improvement in the quality, when performed at an appropriate stage.

EXAMPLE 51

10 kg/10 a, in terms of nitrogen, of a compound fertilizer was applied to a field as the basal dressing and 4 ridges 1 m in width were formed. On Oct. 24, 5 kg/10 a of wheat seeds (norin No. 61) were sowed in 2 lines at intervals of 50 cm.

On May 5 and 10, the seedlings were subjected to foliage treatment with 200 l per 10 a of 5-ALA aqueous solutions of various concentrations each containing a surfactant (neoesterin) diluted 2,000-fold. A section (1 m×1 m) was employed for each condition and 4 lots were employed as treated ones. 8 lots were employed as untreated ones.

On Jul. 12, the plants were harvested and the total grain weight was determined by the random sampling method (20 heads per lot).

Table 63 shows the results.

TABLE 63

5-ALA conc. (ppm)	Yield (g/20 heads)	Ratio to untreated lot (%)
0	31.7	100
10	32.9	104
30	34.1	107
100	36.0	114

As Table 63 clearly shows, treatment with 5-ALA also increased yield in the field test.

EXAMPLE 52

On Apr. 6, spring wheat seeds (haruyutaka) were sowed in a 1/2500 a pot filled with soil to which 10 kg/10 a, in terms of nitrogen, of a compound fertilizer was applied as the basal dressing. Then the plants were grown as 3-stem training in a glass greenhouse under common conditions.

On May 21 and 28, the plants were subjected to foliage treatment with 200 l per 10 a of 5-ALA aqueous solutions of 10, 30 and 100 ppm each containing a surfactant (neoesterin) diluted 2,000-fold. 6 treated lots were employed and 14 lots were employed as untreated ones.

On Jul. 13, the plants were harvested and the total head weight and threshed grain weight (per head) were determined. Table 64 shows the results.

TABLE 64

5-ALA conc. (ppm)	Head weight (g/head)	Ratio to untreated lot (%)	Grain weight (g/head)	Ratio to untreated lot (%)
0	1.53	100	1.17	100
10	1.75	114	1.35	115
30	1.62	106	1.26	108
100	1.65	108	1.28	109

Table 64 shows that treatment With 5-ALA also increased the yield of spring wheat.

EXAMPLE 53

On May 9, kidney bean seeds (Cyprus, Takii & Co., Ltd.) were sowed in a 1/2500 a pot filled with soil to which 15 kg/10 a, in terms of nitrogen, of a compound fertilizer was applied as the basal dressing. Then the plants were grown as 3-stem training in a glass greenhouse under common conditions. The plants were then subjected to foliage treatment with 200 l per 10 a of a 5-ALA aqueous solution of 100 ppm containing a surfactant (neoesterin) diluted 2,000-fold at the points listed in Table 65. 3 treated lots were employed and 6 lots were employed as untreated ones.

On Jul. 3, the plants were harvested and the yield was determined. Table 65 shows the results.

TABLE 65

Date	Stage	Data given in parentheses are based on the untreated lot (%). Pod weight (g/pod)	Yield (g/plant)
Untreated	—	1.30 (100)	10.55 (100)
5/20	True leaf 1	1.50 (116)	12.57 (119)
5/25	Compound leaf 1	1.43 (110)	13.68 (130)
5/31	Compound leaf 2	1.32 (102)	10.71 (102)
6/5	Compound leaf 3	1.06 (82)	9.29 (88)
6/13	Compound leaf 5 (blooming)	1.13 (87)	9.06 (86)
6/18	Early pod appearing	1.24 (95)	11.34 (108)
6/26	Pod maturing	1.31 (101)	11.28 (107)

As Table 65 shows, treatment with the invention agent increased yield. It was found that this treatment was particularly effective when performed in the seedling stage (true leaf period 1 to compound leaf period 2).

EXAMPLE 54

20 kg/10 a, in terms of nitrogen, of a compound fertilizer was applied to a field as the basal dressing and a ridge 2 m in width was formed. On Nov. 1, garlic bulbs (Fukuchi White, Nohara Shubyo, K.K.) were planted in 8 lines at intervals of 25 cm. Then, the plants were managed under common conditions. On Apr. 20 (5.5 leaf stage), when underground bulbs began to mature, the seedlings were subjected to foliage treatment with 200 l/10 a of 5-ALA aqueous solutions of 0, 30, 100 and 300 ppm and a comparative agent (aqueous solution of

a garlic yield-increasing agent Sun-catch, product of Mitsubishi Gas Chemical Co., Ltd.), each containing a surfactant (neoesterin) diluted 1,000-fold.

Each test section (50+50 cm) had 4 plants and the treatment was repeated 6 times for each condition.

The plants were harvested on Jun. 6 and the yield was measured. Tables 66 and 67 show the results.

TABLE 66

5-ALA conc. (ppm)	Underground weight (g/bulb) Data given in parentheses are based on the untreated lot (%).	Bulb size (cm)
Untreated	22.2 (100)	3.94 (100)
30	27.3 (123)	4.18 (106)
100	26.2 (118)	4.19 (106)
300	28.6 (129)	4.26 (108)
Sun-Catch TM (choline chloride; 1,000)	26.0 (117)	4.17 (106)

As Table 66 clearly shows, the treatment with the invention agent remarkably increased yield. This effect exceeded the one achieved by the comparative agent Sun-catch TM . Further, the bulb size was increased by treatment with the invention agent, indicating that the qualities of the garlic were improved.

TABLE 67

5-ALA conc. (ppm)	Ratio of weight/bulb (%) ≧30 g	30 g > and ≧ 20 g	<20 g
Untreated	18	39	43
30	36	28	36
100	37	35	28
300	37	38	25
Sun-catch TM (choline chloride; 1,000)	27	40	33

As Table 67 clearly shows, treatment with the invention agent increased the ratio of large bulbs of higher commercial value and decreased the ratio of small bulbs of lower commercial value. That is to say, it was found out that the quality of the garlic was improved by treatment with the invention agent.

EXAMPLE 55

On Feb. 5, radish seeds (comet, Sakata Shubyo K. K.) were sowed in a 1/5000 a pot filled with field soil to which 10 kg/10 a, in terms of nitrogen, of a compound fertilizer had been applied as the basal dressing. The seedlings were grown as 3-stem training per pot in a glass greenhouse under common conditions. On Mar. 20, (5.5 leaf stage), the plants were subjected to foliage treatment with 200 l/10 a of 5-ALA aqueous solutions of 0 and 100 ppm each containing a surfactant (neoesterin) diluted 2,000-fold. 10 pots were employed for each concentration. Then, the quantity of light was reduced to 40% by covering the plants with cheese cloth and the cultivation was continued in a common manner.

On Apr. 5, the plants were harvested and weighed. Table 68 shows the results.

TABLE 68

5-ALA conc. (ppm)	Total weight (g/plant)	Underground total weight (g/plant)	Ratio of weight of 35 g or more to total weight (%)
0	26.0 (100)	12.4 (100)	15.0
100	32.4 (125)	15.7 (126)	48.2

As Table 68 clearly shows, treatment with 5-ALA increased yield and improved quality even under reduced light conditions.

In the test lot, good plants weighing 35 g or more amounted to almost a half of the total plants, while the ratio thereof in the control lot was as low as 15%. Thus, it was found out that the environmental stress (i.e., light reduction) was relieved by treatment with 5-ALA.

EXAMPLE 56

On May 20, rice seedlings (hoshi-no-hikari; 3 leaf stage) were planted in a 1/2000 a pot filled with paddy field soil to which 30 kg/10 a, in terms of nitrogen, of a compound fertilizer had been applied as the basal dressing. 4 seedlings were planted per pot at a depth of 3 cm. These plants were grown outdoor under common conditions at a water depth of 3 cm. On Jun. 20, the seedlings were thinned so as to give 3 stems per pot. On Jul. 23, 15 kg/10 a, in terms of nitrogen, of a compound fertilizer was applied as the top dressing.

On Jul. 26 (head formation stage) and on Aug. 22 (blooming stage following head appearing stage), the seedlings were subjected to watering treatment with 5-ALA at the concentrations as listed in Table 69. On Oct. 5, the rice plants were harvested. After drying, the head weight per plant was measured. 3 pots were employed for each condition and the average value of 9 plants was calculated. Table 69 shows the results.

TABLE 69

Head weight (dry weight/plant)
Data given in parentheses are based on the untreated lot (%).

No. of treatments (date)	5-ALA conc. (g/10 a) 0	3	10	30	100	300
1 (7/26)	22.0 (100)	24.2 (110)	25.1 (114)	24.5 (111)	25.2 (115)	23.6 (107)
1 (8/22)	22.0 (100)	23.8 (108)	24.2 (110)	24.0 (109)	25.1 (114)	24.4 (111)
2 (7/26, 8/22)	22.0 (100)	23.8 (108)	24.0 (109)	25.4 (115)	26.0 (118)	24.3 (110)

As Table 69 clearly shows, treatment with 5-ALA increased yield. Thus, it was found that the invention agent was also effective when used in watering, namely, when used in soil treatments.

EXAMPLE 57

A field, to which 3 kg/10 a, in terms of nitrogen, of a compound fertilizer had been applied as the basal dressing, was divided into 20 sections (1 m×1 m). Sweet potato seedlings (beniazuma) were soaked in 5-ALA aqueous solutions of concentrations as given in Table 70 and in an aqueous solution of Sun-catch TM for 24 hours. After soaking, the seedlings were planted on Jun. 26 at a ratio of 4 seedlings per section. 3 sections were employed for each condition while 5 sections were employed for untreated seedlings. The seedlings were then managed under common conditions.

On Oct. 18, the plants were harvested and the potato yield per section and the average weight per potato were examined. Table 70 shows the results.

TABLE 70

Data given in parentheses are based on the untreated lots (%).

5-ALA conc. (ppm) 0	0.001	0.01	0.1	1	Sun-catch TM (choline chloride; ppm) 20

TABLE 70-continued

Yield (g/section)	1552 (100)	1677 (106)	1972 (127)	1875 (121)	1634 (105)	1743 (112)
Average wt. (g/potato)	120 (100)	128 (107)	171 (143)	136 (114)	114 (95)	148 (124)

As Table 70 clearly shows, treatment with the invention agent increased yield and improved quality.

EXAMPLE 58

A field, to which 3 kg/10 a, in terms of nitrogen, of a compound fertilizer had been applied as the basal dressing, was divided into 20 sections (1 m×1 m). On Jun. 25, sweet potato seedlings (beniazuma) were planted at a ratio of 4 seedlings per section. 3 sections were employed for each condition while 5 sections were employed for untreated seedlings. The seedlings were then managed under common conditions. On Jul. 18 (23 days after the plantation), the seedlings were subjected to foliage treatment with 100 l per 10 a of 5-ALA solutions of concentrations as given in Table and Sun-catch TM aqueous solution, each containing a surfactant (neoesterin) diluted 2,000-fold.

On Oct. 18, the plants were harvested and the potato yield per section and the average weight per potato were examined. Table 71 shows the results.

TABLE 71

Data given in parentheses are based on untreated lots (%).

	5-ALA conc. (ppm)					Sun-Catch TM (choline chloride; ppm)
	0	10	30	100	300	1,000
Yield (g/section)	3391 (100)	3364 (99)	4648 (137)	3590 (106)	3159 (93)	2617 (77)
Average wt. (g/potato)	231 (100)	249 (108)	344 (149)	248 (107)	226 (98)	201 (87)

As Table 71 clearly shows, treatment with the invention agent increased yield and improved quality.

What is claimed is:

1. A method for promoting the growth of a plant which comprises treating said plant with 1 to 1,000 ppm and 10 to 1,000 l/10 a, in the case of foliage treatment, 1 to 1,000 g/10 a, in the case of soil treatment, or 0.001 to 10 ppm, in the case of soaking treatment, of 5-aminolevulinic acid or a salt thereof.

2. A method for promoting the rooting of a plant which comprises treating said plant with 1 to 1,000 ppm and 10 to 1,000 l/10 a, in the case of foliage treatment, 1 to 1,000 g/10 a, in the case of soil treatment or 0.001 to 10 ppm, in the case of soaking treatment, from 1 hour to 1 week of 5-aminolevulinic acid or a salt thereof.

3. A method for promoting the rooting ratio of a plant which comprises treating said plant with 1 to 1,000 ppm and 10 to 1,000 l/10 a, in the case of foliage treatment, 1 to 1,000 g/10 a, in the case of soil treatment or 0.001 to 10 ppm, in the case of soaking treatment, from 1 hour to 1 week, of 5-aminolevulinic acid or a salt thereof.

4. A method for growing good seedlings of a plant which comprises treating said plant with 1 to 1,000 ppm and 10 to 1,000 l/10 a, in the case of foliage treatment, 1 to 1,000 g/10 a, in the case of soil treatment, or 0.001 to 10 ppm, in the case of soaking treatment, from 1 hour to 1 week, of 5-aminolevulinic acid or a salt thereof.

5. A method for reducing lodging of a plant which comprises treating said plant with 1 to 1,000 ppm and 10 to 1,000 l/10 a, in the case of foliage treatment, 1 to 1,000 g/10 a, in the case of soil treatment, or 0.001 to 10 ppm in the case of soaking treatment, from 1 hour to 1 week, of 5-aminolevulinic acid or a salt thereof.

6. A method for increasing the yield of a plant which comprises treating said plant with 1 to 1,000 ppm and 10 to 1,000 l/10 a, in the case of foliage treatment, 1 to 1,000 g/10 a, in the case of soil treatment, or 0.001 to 10 ppm in the case of soaking treatment, from 1 hour to 1 week, of 5-aminolevulinic acid or a salt thereof.

7. A method for improving the cold resistance of a plant which comprises treating said plant with 1 to 1,000 ppm and 10 to 1,000 l/10 a, in the case of foliage treatment, 1 to 1,000 g/10 a, in the case of soil treatment, or 0.001 to 10 ppm in the case of soaking treatment, from 1 hour to 1 week, of 5-aminolevulinic acid or a salt thereof.

8. A method for maintaining the freshness of a plant which comprises treating said plant with 1 to 1,000 ppm and 10 to 1,000 l/10 a, in the case of foliage treatment, or 1 to 1,000 g/10 a, in the case of soil treatment, of 5-aminolevulinic acid or a salt thereof.

9. A method for maintaining or improving the green color of a plant which comprises treating said plant with 1 to 1,000 ppm and 10 to 1,000 l/10 a, in the case of foliage treatment, 1 to 1,000 g/10 a, in the case of soil treatment, or 0.001 to 10 ppm, in the case of soaking treatment, from 1 hour to 1 week, of 5-aminolevulinic acid or a salt thereof.

10. A method for relieving chemical damage to a plant which comprises treating said plant with 1 to 1,000 ppm and 10 to 1,000 l/10 a, in the case of foliage treatment, 1 to 1,000 g/10 a, in the case of soil treatment, or 0.001 to 10 ppm, in the case of soaking treatment, from 1 hour to 1 week, of 5-aminolevulinic acid or a salt thereof.

11. A method for increasing the number of tillers of a plant which comprises treating said plant with 1 to 1,000 ppm and 10 to 1,000 l/10 a, in the case of foliage treatment, 1 to 1,000 g/10 a, in the case of soil treatment, or 0.001 to 10 ppm, in the case of soaking treatment, from 1 hour to 1 week, of 5-aminolevulinic acid or a salt thereof.

12. A method for shortening the time required for the growth of a plant which comprises treating said plant with 1 to 1,000 ppm and 10 to 1,000 l/10 a, in the case of foliage treatment, 1 to 1,000 g/10 a, in the case of soil treatment, or 0.001 to 10 ppm, in the case of soaking treatment, from 1 hour to 1 week, of 5-aminolevulinic acid or a salt thereof.

13. A method for promoting the growth of an organ of a plant which comprises incubating calluses, shoot primordia or hairly roots of said plant in a medium containing 0.001 to 10 ppm of 5-aminolevulinic acid or a salt thereof for 1 hour to 1 week.

14. A method for enhancing the photosynthetic activity of a plant which comprises treating said plant with 1 to 1,000 ppm and 10 to 1,000 l/10 a, in the case of foliage treatment, 1 to 1,000 g/10 a, in the case of soil treatment, or 0.001 to 10 ppm, in the case of soaking treatment, from 1 hour to 1 week, of 5-aminolevulinic acid or a salt thereof.

15. A method for suppressing the respiration of a plant which comprises treating said plant with 1 to 1,000 ppm and 10 to 1,000 l/10 a, in the case of foliage treatment, 1 to 1,000 g/10 a, in the case of soil treatment, or 0.001 to 10 ppm, in the case of soaking treat-

ment, from 1 hour to 1 week, of 5-aminolevulinic acid or a salt thereof.

16. A method for enhancing the ability to absorb CO_2 of a plant which comprises treating said plant with 1 to 1,000 ppm and 10 to 1,000 l/10 a, in the case of foliage treatment, 1 to 1,000 g/10 a, in the case of soil treatment, or 0.001 to 10 ppm, in the case of soaking treatment, from 1 hour to 1 week, of 5-aminolevulinic acid or a salt thereof.

17. A method for increasing the chlorophyll content of a plant which comprises treating said plant with 1 to 1,000 ppm and 10 to 1,000 l/10 a, in the case of foliage treatment, 1 to 1,000 g/10 a, in the case of soil treatment, or 0.001 to 10 ppm, in the case of soaking treatment, from 1 hour to 1 week, of 5-aminolevulinic acid or a salt thereof.

18. A method as claimed in claim **1**, wherein said plant is selected from rice, barley, wheat, corn, sweet potato, lawn grass, radish, cucumber, soybean, adzuki bean, kidney bean, onion, spinach, komatsuna, rape, potato, garlic or tea.

19. A method as claimed in any one of claims **2** to **7** or any one of claims **10** to **17**, wherein said plant is selected from rice, barley, wheat or corn.

20. A method as claimed in any one of claims **2** to **17**, wherein said plant is selected from beans.

21. A method as claimed in any one of claims **2**, **3**, **6**, **7** and **11** to **17**, wherein said plant is selected from potatoes.

22. A method as claimed in any one of claims **2** to **17**, wherein the foliage treatment is performed with 10 to 500 ppm of 5-aminolevulinic acid or a salt thereof at 50 to 300 l/10 a, the soil treatment is performed with 10 to 500 g/10 a of 5-aminolevulinic acid or a salt thereof, or the soaking treatment is performed with 0.01 to 5 ppm of 5-aminolevulinic acid or a salt thereof for 3 hours to 1 day.

23. A method as claimed in any one of claims **1** to **17**, wherein said salt of 5-aminolevulinic acid comprises one or more compounds selected from among the acid-addition salts hydrochloride, phosphate, nitrate, sulfate, acetate, propionate, butyrate, valerate, citrate, fumarate, maleate or malate and the metal salts sodium, potassium or calcium.

24. A method as claimed in claim **1** for promoting the growth of a plant which comprises treating said plant with one or more compounds selected from other plant growth regulators, sugars, amino acids, organic acids, alcohols, vitamins or minerals in combination with said 5-aminolevulinic acid or a salt thereof.

25. A method as claimed in claim **24**, wherein said other plant growth regulator is epibrassinolide or choline chloride.

26. A method as claimed in claim **24**, wherein said sugar is glucose or sucrose.

27. A method as claimed in claim **24**, wherein said amino acid is selected from among asparagine, glutamine, histidine, tyrosine, glycine, arginine, alanine, tryptophan, methionine, valine, proline, leucine, lysine or isoleucine.

28. A method as claimed in claim **24**, wherein said organic acid is selected from among formic acid, acetic acid, propionic acid, butyric acid, valeric acid, oxalic acid, phthalic acid, benzoic acid, lactic acid, citric acid, tartaric acid, malonic acid, malic acid, succinic acid, glycolic acid, glutamic acid, aspartic acid, maleic acid, caproic acid, caprylic acid, myristic acid, stearic acid, palmitic acid, pyruvic acid, α-ketoglutaric acid or levulinic acid.

29. A method as claimed in claim **24**, wherein said vitamin is selected from among nicotinic acid amide, vitamin B_6, vitamin B_{12}, vitamin B_5, vitamin C, vitamin B_{13}, vitamin B_1, vitamin B_3, vitamin B_2, vitamin K_3, vitamin A, vitamin D_2, vitamin D_3, vitamin K_1, α-tocopherol, β-tocopherol, γ-tocopherol, δ-tocopherol, p-hydroxybenzoic acid, biotin, folic acid, nicotinic acid, pantothenic acid or α-liponic acid.

* * * * *